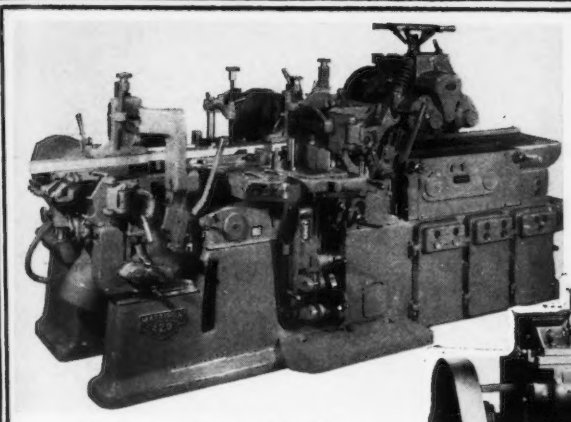
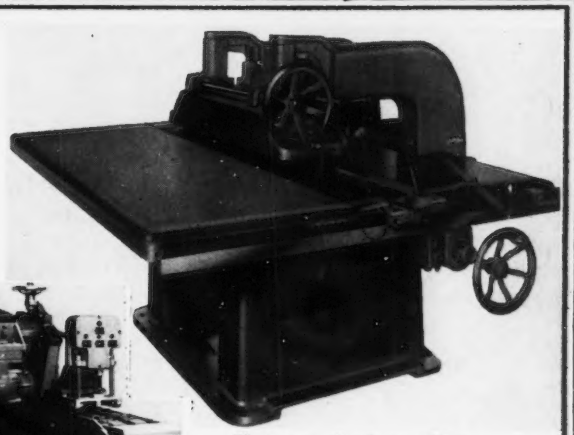
MACHINE SLICES WOOD WITHOUT SAWDUST—p. 319

Forest Products Journal

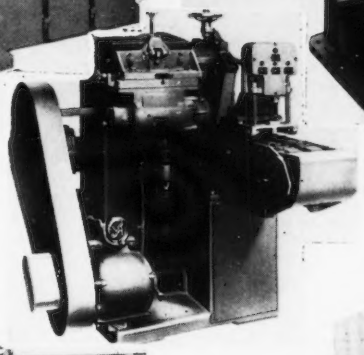
Vol. VI, No. 9 September, 1956



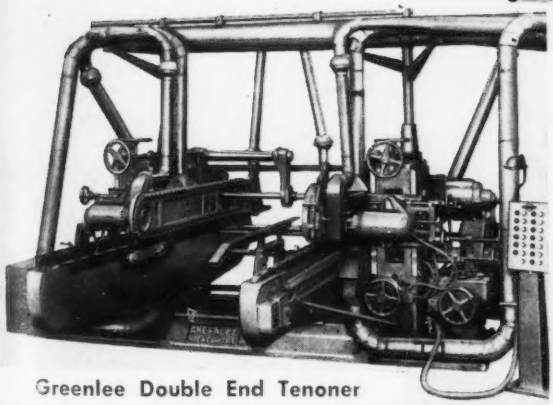
Mattison Electric Moulder



Ekstrom, Carlson Glue Line Rip Saw



Yates–American Finger Jointer



Greenlee Double End Tenoner

Solem 4-Drum Sander

See Modern Woodworking Machinery in Operation at Midwest Section Meeting Oct. 24–26—pp. 10–A, 11–A

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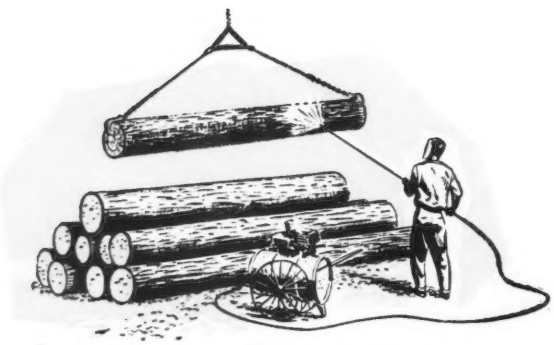
HOW TO PREVENT

costly insect damage and stain

IN LOGS AND LUMBER



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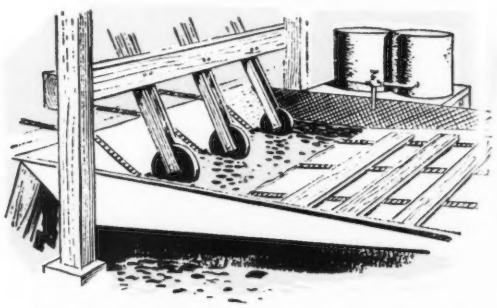

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THE FOREST PRODUCTS JOURNAL is published monthly by the Forest Products Research Society, P. O. Box 2010, University Station, Madison 5, Wisconsin. Entered as Second-Class Matter, April 1952 at the Post Office, at Madison, Wisconsin.

Annual subscription rate, $15.00; single copies $1.00, except October Yearbook Number, $4.00. Annual subscription rate is $11.25 with voting, associate, and supporting memberships in the Society. Remittances should be made payable to the Forest Products Research Society.

Correspondence on editorial matters should be addressed to the Editor, at the Executive Office. The Society is not responsible for views expressed in publications.

FOREST PRODUCTS JOURNAL

Vol. VI, No. 9 September, 1956

CONTENTS

Page

FPRS News–Digest ---- 9–A, 29–A

MACHINING

Greater Utilization of Material Obtained from New Machine ---- W. K. Murphey and G. D. Schneider 319

VENEER AND PLYWOOD

Maintenance of Quality in the Manufacture of Molded Plywood ---- R. A. McKay 321

COMPOSITION BOARD

Insulating Fiberboard Roof Deck ---- P. D. Close 324

SEASONING

Equilibrium Moisture Content Relations and Drying Control in Superheated Steam Drying ---- W. G. Kauman 328

Estimating the Moisture Content of Lumber During the Drying Process ---- W. E. Pratt 333

Prefabricated Dry Kiln Buildings ---- R. H. Elliott 17–A

PROPERTIES

Longitudinal Shear in Wooden Beams ---- J. C. Meadows, Jr. 337

PRESERVATION

A New Method for Long Term Preservation of Wood by Chemical Modification ---- F. G. W. Smith, R. R. Bottoms, E. Abrams, and S. M. Miller 340

CHARCOAL PRODUCTION

An Iranian Charcoal Kiln ---- A. R. Olson 345

BARKING

The Choice of Barker for the Sawmill ---- Panel Discussion 19–A

SAWMILLING

Sawing Rates, Sawdust Chambering, and Spillage ---- L. H. Reineke 348

Modern Electric Drives for the Lumber Industry ---- W. L. Lagers 25–A

DEPARTMENTS

FPRS Employment Service ---- 12–A

Around the World in Forest Products Research ---- 27–A

Abstracts from Current World Literature ---- 28–A

Meet FPRS 100 Company Supporting Members ---- 31–A

Index to Advertisers ---- 32–A

IMPORTANT FPRS DATES

Sept. 24–25, 1956: Joint Meeting of Inland Empire and Pacific Northwest Sections, Lewiston, Idaho

Sept. 28, 1956: Northern California Section Meeting, Reno, Nevada

Oct. 16, 1956: Upper Mississippi Valley Section Meeting, Wausau, Wisconsin

Fall 1956: Carolinas–Chesapeake Section Annual Meeting, Pinehurst, N. C.

Oct. 24–25, 1956: Midwest Section Meeting, Rockford, Ill.

Oct. 25–26, 1956: Northeast Section Meeting, New York City

Oct. 29–31: Mid-South Section Annual Meeting, Laurel, Miss.

Dec. 7–8: Florida–Georgia–Alabama Section Annual Meeting, Athens, Ga.

March 1957: Eastern Canadian Section Annual Meeting, Montreal, Quebec

June 24–28, 1957: Eleventh National Meeting, Buffalo, N. Y.

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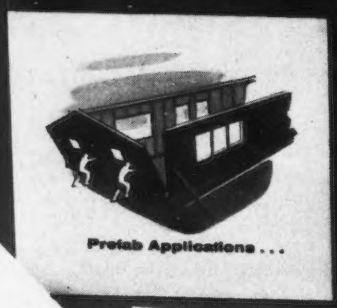

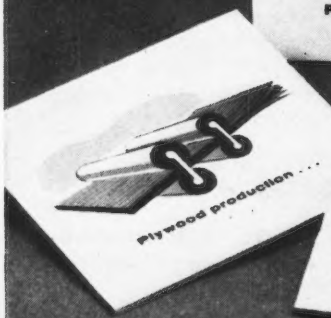

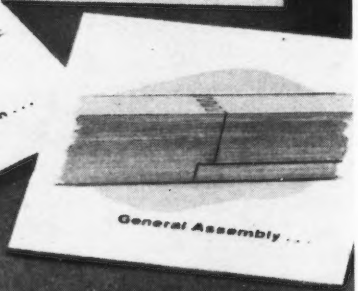

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Soybean and Soybean Blend... unexcelled for low-cost production of interior grade water-resistant plywood by cold press and No-Clamp methods.

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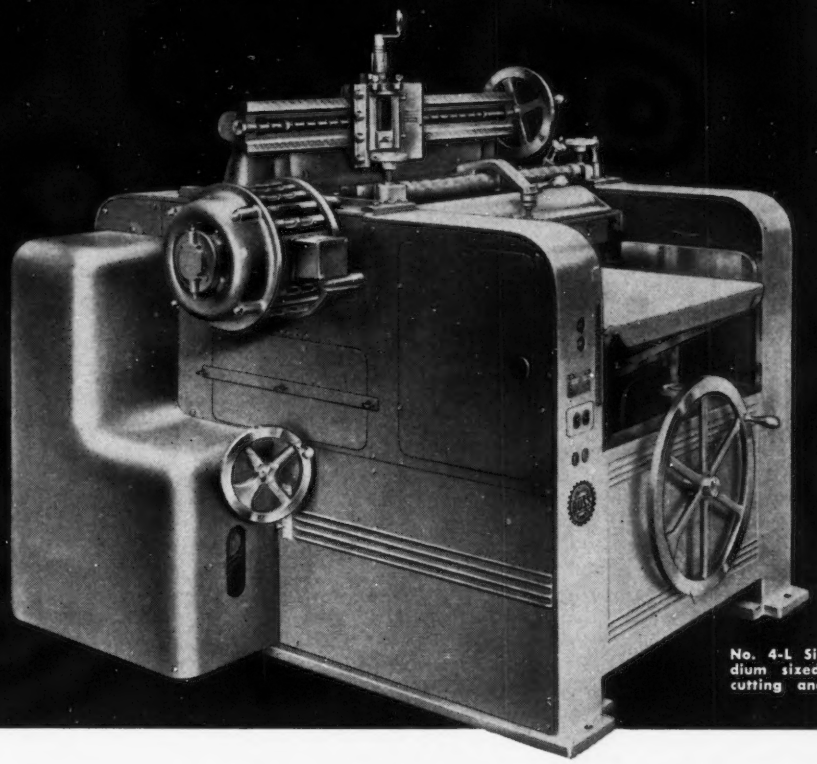

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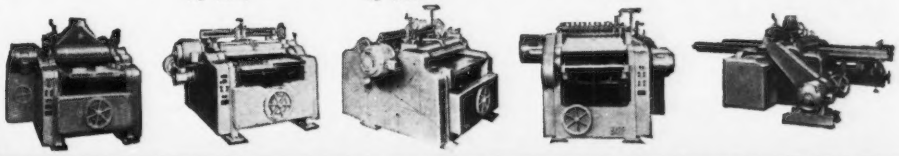

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PENACOLITE®–laminated arches

specified for Long Island Arena

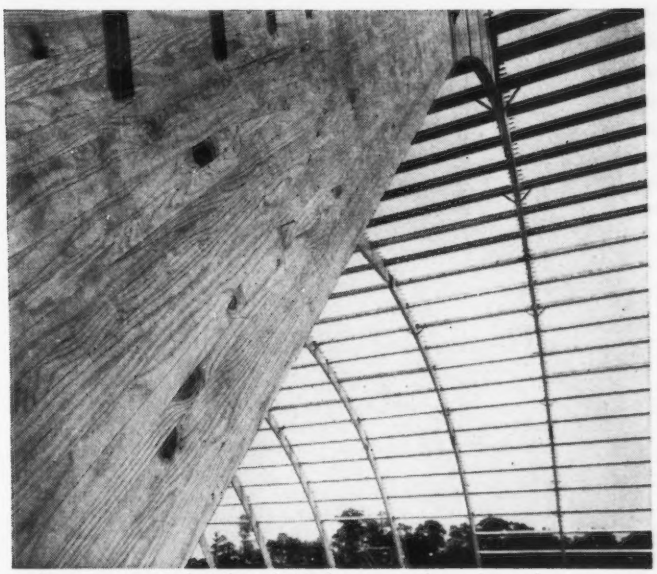
Construction has just been completed on this big arena erected at Commack, Long Island, by Roof Structures, Inc., of New York City. The arena is designed for professional ice hockey games, as well as other sports events and exhibits, and will be subjected to an unusual amount of dampness during freezing and thawing operations. PENACOLITE adhesives were selected to bond the Southern Pine laminated arches, because the bonds are completely waterproof and unaffected by atmospheric humidity and temperature changes.

Furthermore, PENACOLITE adhesives are easily and quickly applied, and they will set, even at room temperature, into bonds as strong as the woods they join. They will not weaken with age or long exposure.

Mr. William Linck, President of the Long Island Arena Corporation, states: "We are highly pleased with our selection of PENACOLITE laminated arches. Their erection is very rapid, their over-all cost is less than any other materials we considered, and the natural beauty of wood is obtained in a structural material. We feel that we made the best selection possible."

Investigate PENACOLITE adhesives by sending for our free, illustrated booklet describing their many uses. Koppers Company, Inc., Dept. FPJ-96, Chemical Division, Pittsburgh 19, Pennsylvania.

Here a construction worker checks positioning of arch section on concrete buttress. Stephen Distler of Roof Structures, Inc., says: "PENACOLITE-laminated arches resist humidity better than any others, and will last indefinitely."



Arches soar to a height of 63 feet—equal to that of a six-story building. Each is composed of 28 laminations, all bonded with PENACOLITE adhesives.

Architect: James Van Alst, Centerport, New York.

Twelve PENACOLITE-bonded Southern Pine arches, manufactured by Unit Structures, Inc., Peshtigo, Wisconsin, span 17,000 square feet of floor space in this new arena. 206 feet wide and 350 feet long, the arena will seat 7,000 persons.

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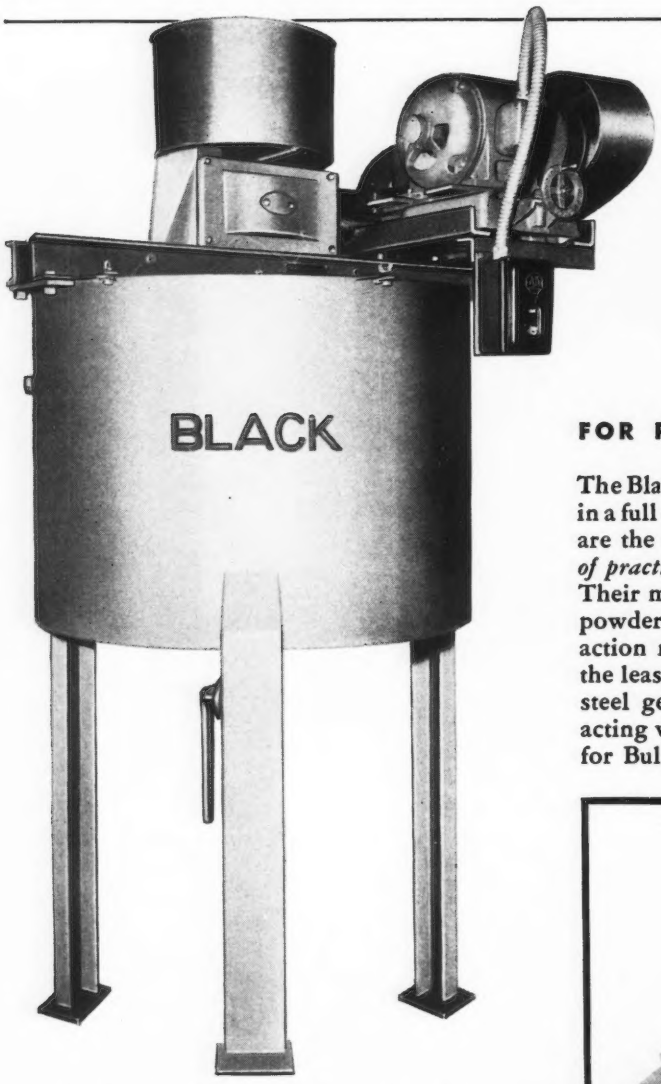
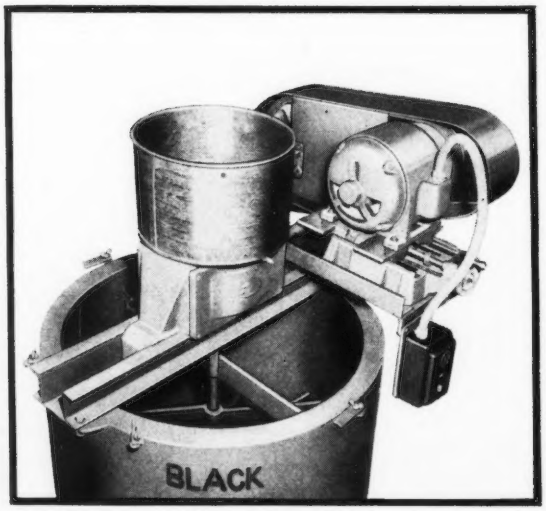


Cold glue MIXERS

FOR POWDERED OR LIQUID ADHESIVES

The Black Brothers stationary cold glue mixers are made in a full range of capacities from 10 to 500 gallons. They are the result of *expert engineering combined with years of practical experience in glue equipment manufacturing.* Their many special features include: (1) Sifter for glue powder (2) Double agitators which give a beating action resulting in the smoothest possible mixture in the least possible time (3) Pressure lubrication (4) Cut steel gears . . . hardened and lapped (5) Large quick-acting valve at bottom. For full information write today for Bulletin 11-I.

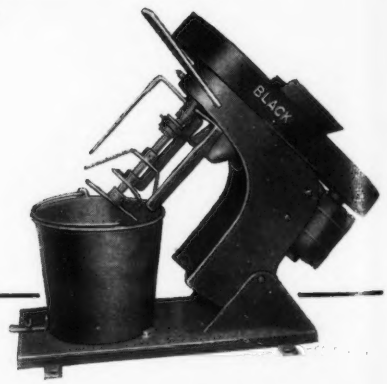


TWO-WAY AGITATION ▶

To the right is a partial view of a 60 gallon cold glue mixer arranged with a variable speed drive and water jacket. The covers have been removed showing accessibility for cleaning, and also the double agitator arrangement. Note the thick double walled tank permitting free circulation of water for cooling the glue batch.

PORTABLE MOTOR DRIVEN GLUE MIXER ▶

The Black Brothers portable motor driven cold glue mixer is made in 2, 5, 7½, and 15 gallon sizes. It has a number of exclusive Black Brothers features such as a glue powder sifter, two-way agitation, and specially shaped flat paddles to give a beating action to the agitator. In addition this convenient, portable mixer has a hinged arm that may be swung up to allow the pail to be inserted or removed. This mixer is also being used extensively in the mixing of catalysts and hardeners. Write for Supplement to Bulletin 11-I.



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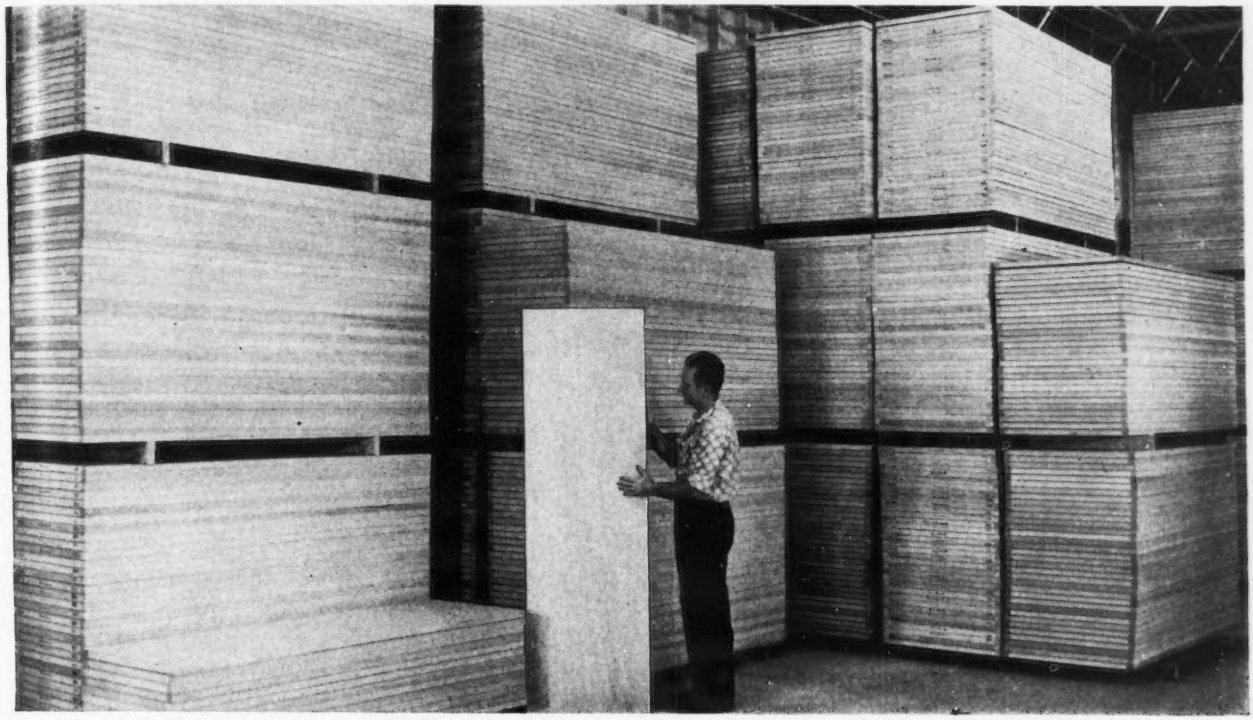

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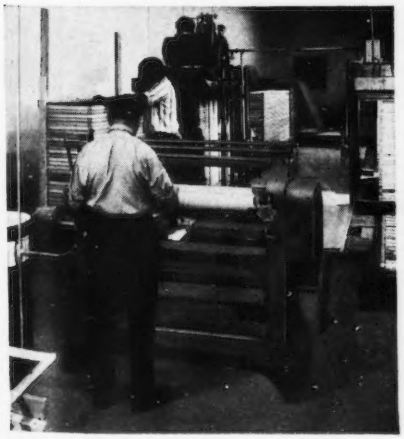

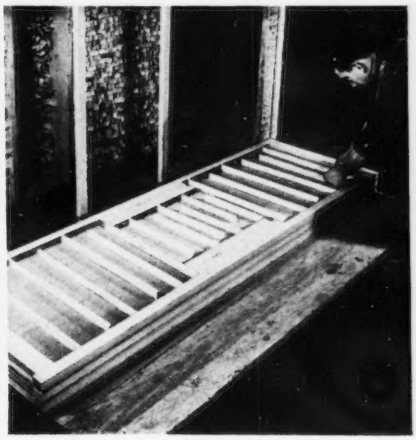

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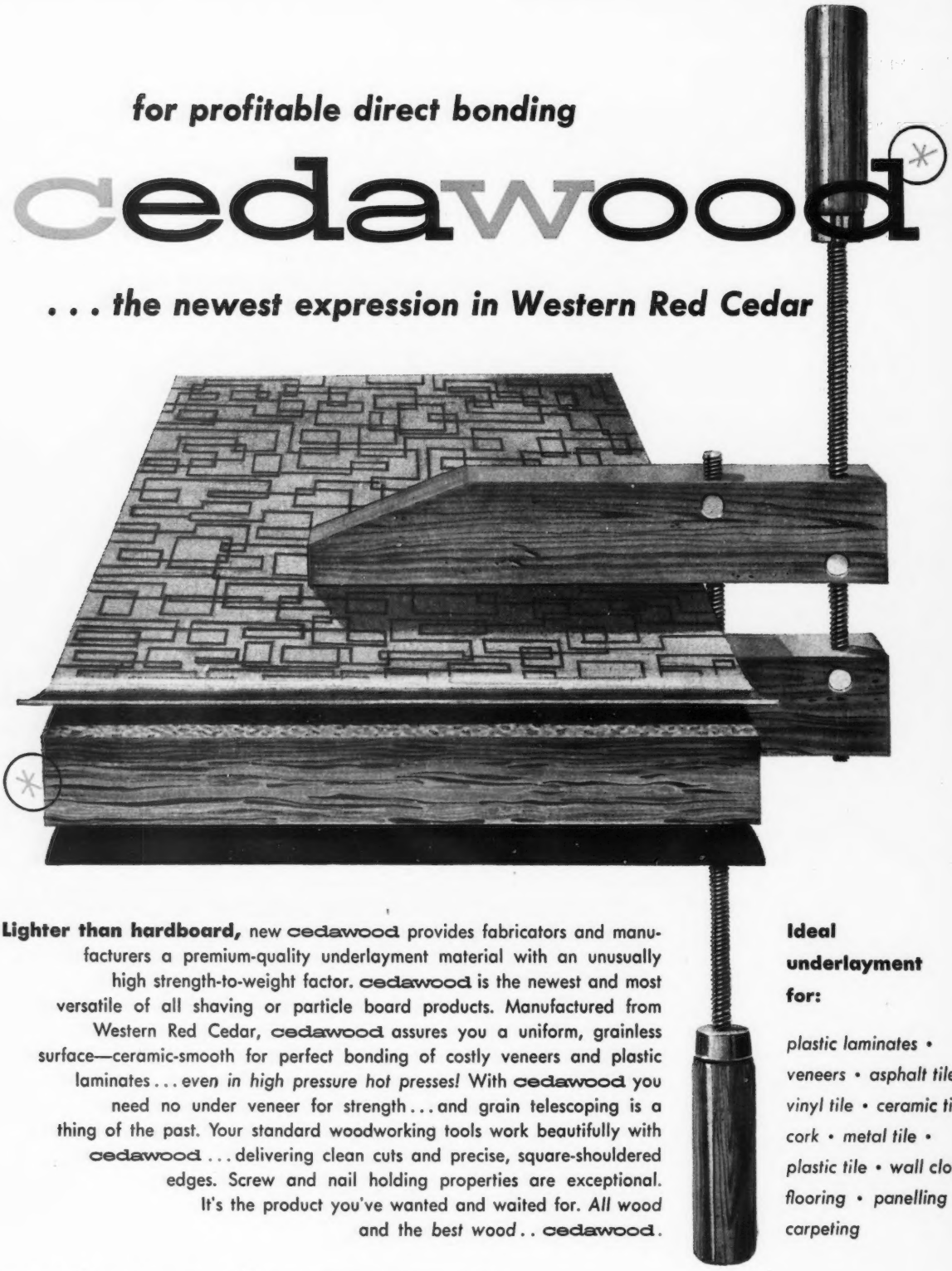

Lighter than hardboard, new cedawood provides fabricators and manufacturers a premium-quality underlayment material with an unusually high strength-to-weight factor. cedawood is the newest and most versatile of all shaving or particle board products. Manufactured from Western Red Cedar, cedawood assures you a uniform, grainless surface—ceramic-smooth for perfect bonding of costly veneers and plastic laminates . . . even *in high pressure hot presses!* With cedawood you need no under veneer for strength . . . and grain telescoping is a thing of the past. Your standard woodworking tools work beautifully with cedawood . . . delivering clean cuts and precise, square-shouldered edges. Screw and nail holding properties are exceptional. It's the product you've wanted and waited for. *All wood* and the *best wood* . . cedawood.

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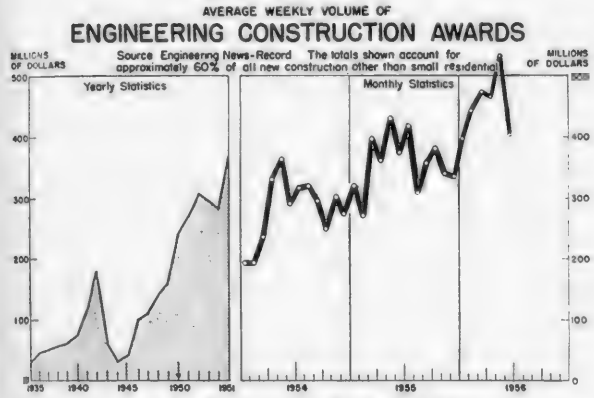
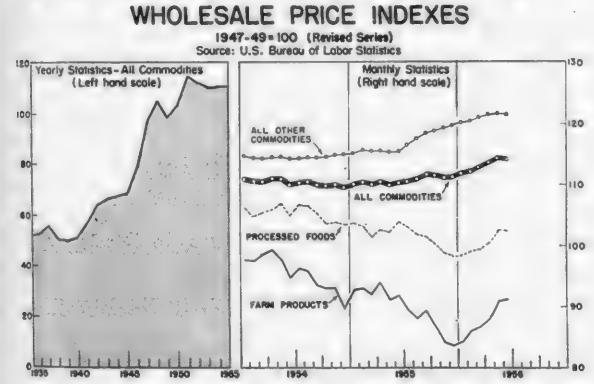
Plant and process by Industrial Development Company, Inc., Tacoma 2, Washington

FPRS NEWS-DIGEST

Volume VI SEPTEMBER, 1956 Number 9

GRAPHIC TRENDS





HEALTHY BUILDING ACTIVITY for next decade was predicted by Economist C. F. Roos, head of Econometric Institute, New York City, in address before annual meeting of Douglas Fir Plywood Assoc. He forecast general up-trend in nation's economy which will firm up plywood demand for rest of year and build up to 25 per cent rise in plywood sales by 1966.

—Veneers and Plywood

NEW RECORD for first six months' furniture factory shipments was chalked up, with 15% lead over same period in '55, according to Seidman & Seidman. June orders climbed 15% above May but dropped 2% in dollar volume compared to last June.

—Veneer Newsletter

BUSINESS OUTLOOK

U. S. LUMBER PRODUCTION accounts for more than a third of the world's output, according to 1956 edition of Facts About the Nation's Lumber Industry, released by AFPI. About 90 per cent of U. S. output of 37 billion board feet is harvested from privately owned commercial forest land. Nearly 70 per cent of each tree harvested is now utilized, the book reports, compared to 30 per cent in the early days of the industry.

INCREASING SHORTAGE of scientific personnel is foreseen by T. S. Hodgins, Vice-President of Research, Reichhold Chemicals, Inc. Supply of scientists and engineers in 1960 is expected to be 200,000 short of country's needs, gap may widen to half million by 1975. Shortage can be stemmed by revising personnel policies, raising compulsory retirement age limits, intensifying training programs, encouraging high school students to make a career in field.

—By Gum

URGENT RESEARCH NEEDS of lumber industry are: more efficient, economical glues and gluing methods; economical means of increasing wood's fire resistance; utilization of residuals; development of more products to permit broader diversification; and dimensional stabilization. Prospect of increasing quantities of raw materials, larger timber inventories, intensive competition all argue for speed-up in product improvement and new product development to guard against market displacement.

—NLMA Annual Report

SOCIETY NEWS

Two Sections Schedule Joint Meeting at Lewiston

The Inland Empire Section will be host at a joint meeting with the Pacific Northwest Section Monday and Tuesday, Sept. 24–25, in Lewiston, Idaho. Technical sessions will be held on both mornings, with plant tours scheduled afternoons. Meeting headquarters will be the Lewis and Clark Hotel.

Two national officers of FPRS will be among speakers at the meeting. President Ralph H. Bescher will be principal speaker at a dinner Sept. 24 and a luncheon on the second day will be addressed by W. Jeter Eason, FPRS Vice-President.

The opening technical session will feature a talk by James T. Lendrum, Director, Small Homes Council, U. of Illinois, on Building Research and the Lumber Manufacturer: Trends and Their Effect on the Man in the Production End of the Lumber Business. Other speakers at this session will be: V. V. Vallandigham, Assistant Manager, Paper Division, Potlatch Forests, Inc., Present and New Uses of Paperboard; J. W. Talbott and T. M. Maloney, Division of Industrial Research, Washington State College, Properties of Boards Composed of Green Planer Shavings from an Inland Empire Mill.

Following luncheon in the Potlatch Forests Cafeteria, attendees will tour the Potlatch sawmill, planing mill, gluing operations, and 2 x 4 laminating pilot plant.

Speakers at the Tuesday session will be: W. Smith, Chief Engineer, Rader Engineering and Pneumatics, Ltd., Vancouver, B. C., The Movement of Pulp Chips, Shavings, Hog Fuel, etc., by Air Systems; F. W. Guernsey, Forest Products Laboratories of Canada, Vancouver, High Temperature Drying of British Columbia Softwoods; and F. J. Shelton, Reichhold Chemicals, Inc., Adhesives Manufacturers' Status Report on Direct Fired Dryers.

Registrants will have a choice of two plant tours in the afternoon. One group will visit the Potlatch pulp mill and veneer mill and another will tour the hydraulic laboratory and wood technology laboratory at Washington State College, Pullman.

Great Lakes Section Planning Fall Meeting

Nov. 8 and 9 have been tentatively selected as the dates for a fall meeting of the Great Lakes Section, according to Chairman Gardner Garlick. Preliminary plans call for plant tours in the morning Nov. 8 and afternoon Nov. 9, with technical sessions in the afternoon Nov. 8 and morning Nov. 9.

Four trustees have been appointed to work with the officers in directing Section activities. They are: Stephen B. Preston, U. of Michigan; Jac H. Tigelaar, Haskelite Manufacturing Co.; Wayne F. Hutchins, American Seating Co.; and A. J. Panshin, Michigan State U.

A contribution of $250 to the FPRS Executive Office Building fund has been voted by the Section officers.

Northeast Section Announces Plans for Fall Meeting

Use of Wood in Modern Home Construction will be the theme of the fall meeting of the Northeast Section Oct. 25–26 at the Prince George Hotel, New York City. Three technical sessions are planned, as well as an afternoon of informal group discussions.

Herbert Seidel of Reisen Lumber Co. will lead a discussion on merchandising, and research in wood products will be discussed by a group under the direction of Prof. F. F. Wangaard, Yale U. Prof. Harry Rich of U. of Massachusetts will lead a discussion on seasoning problems, and Prof. John M. Yavorsky, New York College of Forestry, will be in charge of a group concerned with education for the forest products industry.

Luncheon speaker will be Leonard G. Haeger, technical director of Levitt & Sons, who will speak on "Trends in the Utilization of Wood in the Home Today and in the Future."

Technical papers will include: The Current Status of Carbide Tools in the Woodworking Industry, R. V. Reynolds, Kennametal, Inc.; Machining of Hardboard, E. M. Davis, U. S. Forest Products Laboratory; The Unexplored Facts of Wood in Home Construction, Caleb Hornbostel, New York architect; and Use of Wood in New York State, Prof. R. J. Hoyle, New York College of Forestry.

Northern California Section Announces Meeting in Reno

A tour of the Vaughn Millwork Co. operation will open a meeting of the Northern California Section at 2 p.m. Sept. 28 in Reno, Nevada. Following a social hour, dinner will be served at the Mapes Hotel. Featured speaker of the evening will be Bill McCudden, Research Engineer of Diamond Match Co., who will speak on Automation in the Planing Mill.

Chipman Produces Atlas "A"

Atlas "A" sodium arsenite was erroneously referred to on page 39 of the January 1956 issue of FOREST PRODUCTS JOURNAL as a product of Chapman Chemical Co. This is a product of Chipman Chemical Co., Bound Brook, N. J.

See These Modern M

Five Leading Woodworking Machinery Manufacturers To Operate Equipment at Midwest Section Meeting

How to Get the Most Out of New and Existing Woodworking Machinery is the theme of the Midwest Section Meeting and Machinery Demonstration to be held Oct. 24 and 25 in Rockford, Ill. The meeting, with headquarters in the Faust Hotel, is expected to attract 300 registrants, according to General Chairman Walter Hagstrom and Midwest Section Chairman L. J. Fitzpatrick.

The meeting will emphasize the newest woodworking machinery, which will be demonstrated in operation at the following Rockford area plants: Ekstrom, Carlson & Co., Greenlee Bros. & Co., Mattison Machine Works, Solem Machine Co., and Yates–American Machine Co.

Technical sessions on new developments in woodworking machinery and maintenance will be held on both mornings. Plant tours will occupy the afternoons, with transportation to be provided to and from the plants. Additional plant visits may be arranged on Friday, Oct. 26, for persons desiring to visit further with machinery manufacturers.

The opening technical session will include papers on MAPI Method of Equipment Analysis, a scientific approach for determining the right time for equipment replacement; and Cost Reduction, how to raise the woodworking industry's annual improvement factor through proper utilization of new and existing equipment. Representatives of machine manufacturers will participate in a panel discussion on What Is New In Woodworking Machinery.

The Section's Official Luncheon will be held at noon, Oct. 24, and a Paul Bunyan Hour will take place following the afternoon machinery demonstrations.

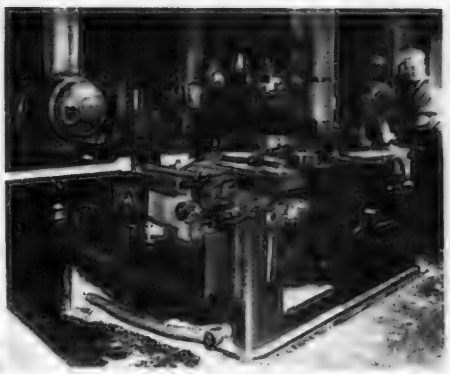
Safety in Woodworking Machine Operation, Maintenance of Machinery, and Electro-Dynamic Balancing of Cutterheads will be discussed on the second day's program, followed by a panel discussion on What Is Needed in Woodworking Machinery, presented by representatives of furniture, millwork, plywood, and prefabricated housing industries. The Section Business Meeting will close the program, to be followed by machinery demonstrations throughout the afternoon.

Ekstrom, Carlson will have its complete line of woodworking machines exhibited under power, including the

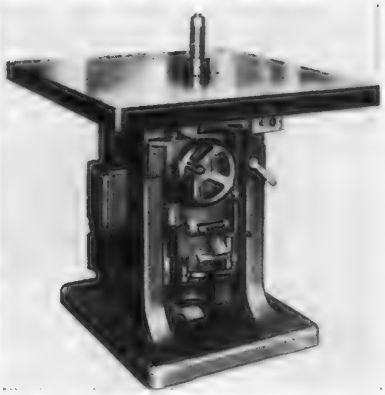
(Continued on page 12-A)

Machines in Operation at Rockford–Beloit Oct. 24–26

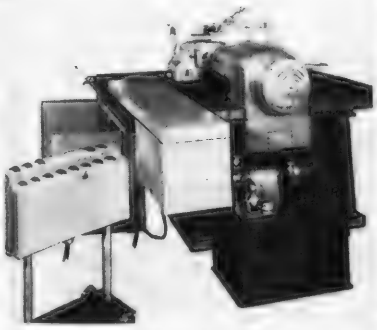
OSCILLATING EDGE BELT SANDER, Ekstrom, Carlson 112A, is used for sanding square, curved, or irregular pieces, as well as hexagonal and octagonal turnings. Belt and back platen oscillate up and down in synchronism.



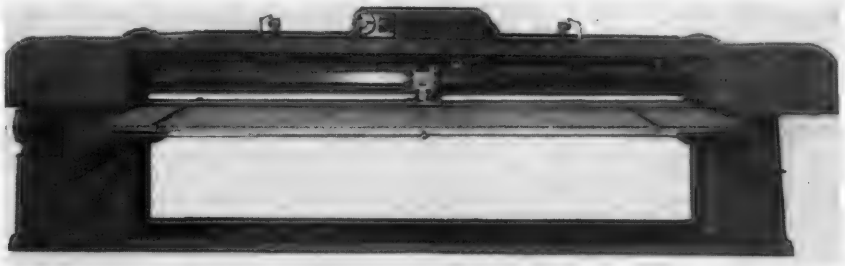
HI-SPEED MOULDER, Ekstrom, Carlson 468, can be run at any of 5 pre-selectable spindle speeds from 3600 to 7200 r.p.m. Variable feed adjustment provides for setting any feed rate between 25 and 225 feet per minute.



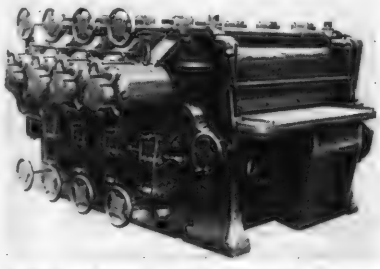
HI-SPEED SHAPER, Ekstrom Carlson 162, is used for regular or irregular contoured work, as well as straight-line tonguing, grooving, jointing, fluting, rabbeting. Two double-spindle shapers are also made.



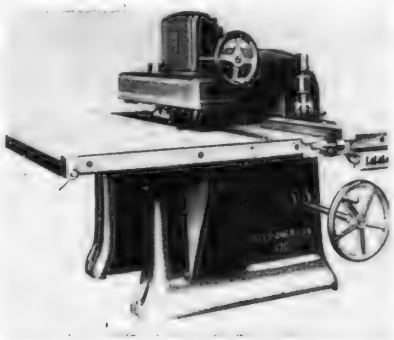
PRE-SELECT WIDTH SAW GAUGE on Mattison 202 Straight Line Ripper has remote push-button control for setting hydraulically actuated gauge to desired width.



AUTOMATIC STROKE SANDER, Mattison 12-foot 303 model, with stabilized stroke, is used for finish sanding large flat surfaces such as tops, panels, doors, etc. Double belt model, with coarse belt for removing tape and glue and fine belt for finish sanding, speeds up production by reducing handling time. This sander, with built in table, is available in 6-foot, 8-foot, 10-foot, and 12-foot size lengths.

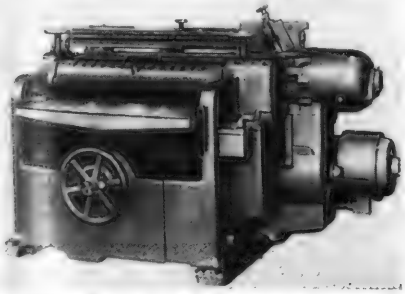


8-DRUM DOUBLE DECK SANDER, Yates–American S–800 model, is reported to hold to extremely close tolerances and at same time sand on both sides of material. New use for this is sanding particle board.

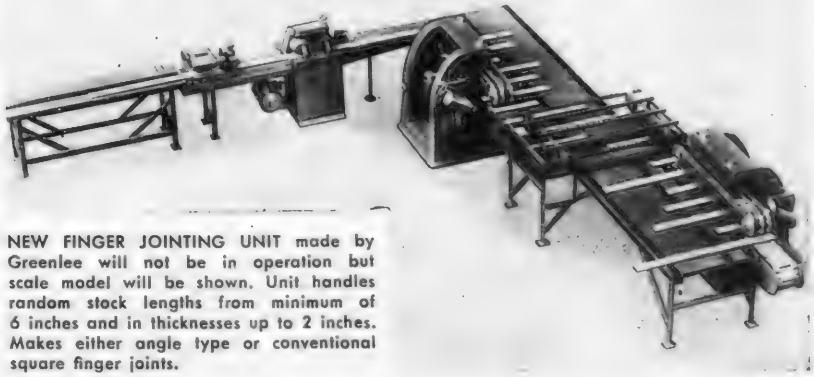


STRAIGHT LINE RIP SAW, Yates–American G–70, is used in furniture and millwork plants where "building up" boards is an effective salvage operation.

DOUBLE-DECK 8-DRUM SANDER, Salem SR 8–8, shown in operation in Oregon fir plywood plant. Each drum motor is push-button controlled and ammeters show sanding load on each drum.



SINGLE-SURFACE PLANER, Greenlee model 110, will be in operation during the Midwest Section Meeting. It is one of a line of single- and double-surface-planers made by Greenlee.



NEW FINGER JOINTING UNIT made by Greenlee will not be in operation but scale model will be shown. Unit handles random stock lengths from minimum of 6 inches and in thicknesses up to 2 inches. Makes either angle type or conventional square finger joints.

Midwest Meeting

(Continued from page 10-A)

new style 6- and 8-inch Hi-Speed Moulders, the model M and MM Glue Line Rip Saws, and a completely new pneumatically operated Direct Line Cut-Off Saw.

Greenlee Bros. & Co. will demonstrate in action the 110 Single Surface Planer, 545 Double End Tenoner, and 431 Roll Feed Rip Saw. They will also have a scale model of their new finger jointing unit on display. The plant has three or four new items in process which may be completed and ready for operation at the time of the meeting.

Machines to be demonstrated at the Mattison Machine Works will include: No. 202 Straight Line Ripper with the preselect width saw gauge, No. 276 Fast Feed Electric Moulder, No. 229 Electric Moulder, and the No. 303 Automatic Stroke Sander. Mattison also has several other new models "under wraps" which will be demonstrated.

Solem Machine Co. will demonstrate one or more of the following: SE7–4 49-inch 4-Drum Sander, SR8–8 49-inch 8-Drum Double Deck Sander, and 55-inch 8-Drum Sander.

Featured at the Yates–American plant in Beloit are to be a number of machines which are of current interest because of new applications or new design. Among those demonstrated will be the S–800 8-Drum Double Deck Sander, Endless Bed Sander, E–10 Finger Jointer, and carbide-tipped tongue and groove side head. Also shown will be the J–120 20-inch band saw, Y–1300 30-inch band saw, B–244 surfacer, and B–101 Hand Jointer.

Hardwood Veneer and Plywood Theme of Upper Miss. Meeting

Manufacture of Hardwood Veneer and Plywood will be the theme of the fall meeting of the Upper Mississippi Valley Section Oct. 16 in Wausau, Wis., according to Paul H. Lane, program chairman. Section Chairman Howard Olson will preside.

Foreign and Domestic Woods for Cores and Crossbands will be the subject of five industry representatives during a panel discussion at the opening afternoon session. This will be followed by a technical paper relating to veneer and plywood manufacture and a movie on research in veneer cutting techniques at the U. S. Forest Products Lab. The slow motion picture shows veneer being cut on the lathe with enlarged views to show knife checks and roughness occurring in the cutting operation.

A tour of Underwood Veneer Co. will complete the afternoon program, to be followed by dinner and a talk by an industry leader.

EMPLOYMENT SERVICE

Positions Offered

No. E 232—Forest products research organization desires new or recently graduated forest products or wood technology major, preferably with basic chemistry, advanced degree and/or experience in forest products. Possibility of work in several fields. (Sept.)

No. E 235—Several openings available on staff of an expanding industrial research and development laboratory, located in East. Consideration will be given recent wood technology or utilization graduates, as well as those having 5 to 10 years' experience in forest products fields. Heavy mathematics, engineering, or chemical background preferred.

No. E 240—Several openings available in hardboard and chipcore plants in various sections of the U. S. Seek men with experience in these fields who are capable of managing production. Technical men also needed.

No. E 241—Sales of glued laminated structural members. Must be willing to spend several months in engineering and/or estimating dept. to learn product and services. Sales are made through promotion to architects & engineers. Position requires transfer to various company offices for permanent assignment. Forest products degree or forestry training with engineering and/or construction background required. (Oct.)

No. E. 242—West Coast wood research laboratory has opening for recent graduate in chemical engineering. Work will involve pilot plant operation in connection with wood extractives, solvent and vapor seasoning, and associated projects. (Sept.)

No. E 243—Wood preserving plant in South seeks man with forestry background for sales position. Principal duties would be securing timber cutting rights. (Sept.)

No. E 244—West Coast plywood company producing interior and exterior Douglas-fir, also hardwood panels, seeks experienced superintendent. (Oct.)

No. E 245—Experienced foreman versed in all mill, assembly and finishing operations for free standing wood store fixture production. Successful, growing factory now employing 60. Pleasant working conditions, congenial people, beautiful community. Ideal location hunters, fishermen and hay fever sufferers. Write Freedman Artcraft Engineering Corp., Charlevoix, Mich. (Oct.)

Employment Wanted

No. 366—University of Michigan Wood technology graduate, holds degree of Forester–Engineer from Germany, seeks production or managerial position in the wood industry. Master of five languages, would like position with opportunity for advancement. Age 29, married.

No. 367—Civil engineer, cabinet maker, 25 years' experience in sawmilling, prefab housing, and furniture, desires position as industrial engineer or administrator in U. S. or Canada. Broad experience in Europe, Canadian citizen, age 42.

No. 368—Forest Management, Sept. Graduate, M.S. Colorado A & M, B.S. Louisiana State. Graduate work has included study of marketing systems for Colorado forest products. Age 26, single. (Oct.)

No. 369—Management position in hardboard or particle board industry desired. Six years experience in wood processing, control, research, development, and sales in hardboard and chipcore industry. B.A., major Chemistry. Age 32. Will locate any area. (Oct.)

Opportunities

WITH THE DEVELOPMENT DEPARTMENT OF A LEADING PRODUCER OF WOOD INSULATION PRODUCTS—BOTH BLANKET AND BOARD—LOCATED IN NORTH-CENTRAL U.S.

Positions Offered:

1. **ORGANIC CHEMIST** with good background in pulp and paper science and knowledge of high polymers for applied research in basic problems of processes and products involving wood fiber, textile fiber, structural, heat and sound insulating building materials and packaging materials. Advanced degree in chemistry with one or two years experience desirable. Salary commensurate with qualifications and experience.

2. **RESEARCH PHYSICIST** or research engineer with MS training or equivalent having background and interest applicable to fundamental mechanical properties of materials, heat transfer, moisture transfer or sound absorption and sound isolation characteristics of fibrous and porous materials. One or two years industrial experience desirable. Salary commensurate with qualifications and experience.

3. **DESIGN & DEVELOPMENT . . .** Personable, market-minded man for design and development of building products for structural, insulating and decorative uses. Varied and expanding program will include travel, consumer contacts, and liaison with Sales. College graduate with technical background and 5–10 years experience is preferred. Salary commensurate with qualifications and experience.

4. **CHEMICAL OR MECHANICAL ENGINEER,** top quality, BS or MS, with leadership qualities for process engineering phases of development work involving use of wood fiber and textile fibers as basic raw materials of structural, insulating and cushioning fiber products. Experience of 5–10 years required which has included supervision of others in carrying projects from initial stages through to commercialization. Initiative, drive, thoroughness and understanding of basic engineering fundamentals are important qualifications. Salary commensurate with qualifications and experience.

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Particle board: the material with a future Securing economical production

18 years ago Siempelkamp produced the first particle board press plant in the world.

Today, with the know-how and experience obtained by numerous deliveries, Siempelkamp builds f u l l y a u t o m a t i c p a r t i c l e b o a r d p r e s s p l a n t s .

This advanced position which Siempelkamp holds in this line is secured by many patents and claims.

At present automatically operating Siempelkamp particle board press plants with an output of

1800 tons per day

are being built. Why not profit from our experience and request technical advice from us without any commitment.

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YOUR GUIDE TO *Better* ADHESIVES . . .

The Perkins Trade Mark is your guarantee of quality and reliability when you purchase glues. Since 1899, customer-confidence in Perkins has grown steadily—a deserved tribute to superior products backed by competent service and rigid ethical standards. When you use a Perkins Glue in your operations, you'll agree with other leading woodworkers—*that Perkins serves you best!*

GLUING PROBLEMS?

Dispose of them by calling upon the skilled assistance of the Perkins Technical Service Department. Specialists in gluing methods will study your particular operations and offer suggestions where pertinent. There is no cost or obligation involved in your use of this unbiased advice.

IT'S A PERKINS SERVICE!

RESIN—Hot Press and Cold Press • Liquid or Powder Type
CASEIN—A broad line to meet your specific requirement
VEGETABLE—As originated and perfected by Perkins Glue Co.
ANIMAL—Ready-to-use Liquid • Heat-then-use Gel

• • •

VENEER AND CORE REPAIR COMPOUNDS • VENEER SIZE
GLUE ROOM SPECIALTIES • MIXERS • SPREADERS • BRUSHES

RESIN
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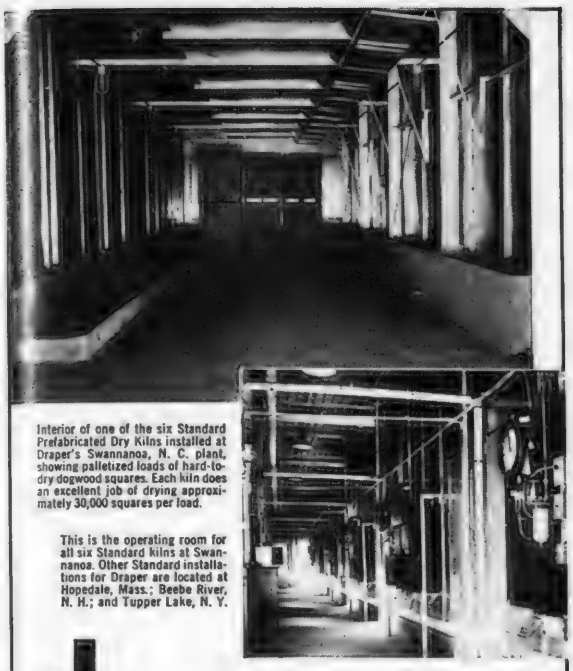
PERKINS

VEGETABLE
GLUES

ESTABLISHED 1899

LANSDALE, PA. KITCHENER, ONT.



Interior of one of the six Standard Prefabricated Dry Kilns installed at Draper's Swannanoa, N. C. plant, showing palletized loads of hard-to-dry dogwood squares. Each kiln does an excellent job of drying approximately 30,000 squares per load.

This is the operating room for all six Standard kilns at Swannanoa. Other Standard installations for Draper are located at Hopedale, Mass.; Beebe River, N. H.; and Tupper Lake, N. Y.

Draper chooses standard draper chooses standard draper chooses standard

Yes, the Draper Corporation certainly *does* choose Standard . . . again and again . . . for *all* its dry kiln requirements. Manufacturers of bobbins and shuttles, Draper has its main plant at Hopedale, Massachusetts, where a Standard prefabricated research kiln was installed several years ago to establish whether it could dry dogwood satisfactorily. As a result of this exhausting research, Draper erected a new plant at Swannanoa, N. C. and installed six Standard Prefabricated Dry Kilns!

At last count, this well-known firm had over 20 Standard kiln installations, and was calling on Standard to remodel six additional kilns at its Hopedale plant . . . *further testimony to the superiority of Standard's efficient direct-driven, internal-fan system!*

BEFORE YOU BUY . . . GET THE FACTS FROM STANDARD

WRITE FOR FREE, ILLUSTRATED CATALOG!

Manufacturers of Internal Fan Kilns

STANDARD

Engineers and Manufacturers Since 1927

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BRANCH OFFICE: REDMAN ENGINEERING SERVICE • HIGH POINT, N. C.

Keeping the Lines of Communication Open

PITTSBURGH, AUG. 22—As I write this, I am very happy to note that eleven of our thirteen Sections have already scheduled fall or winter meetings, starting with our Northern California Section, September 14 at Eureka, and continuing through our Eastern Canadian Section meeting in Montreal next March.

R. H. Bescher

Next week I will be meeting with our Northeast Regional Board Member and General Chairman of the 1957 Buffalo National Meeting, Charlie Lockard, and his able committee. Following this I and our new Vice-President, Jeter Eason of Memphis, Tenn., will attend the joint meeting of the Inland Empire and Pacific Northwest Sections at Lewiston, Idaho on September 24–25. This is one of those fortunate occurrences when two or more of our Sections plan a joint meeting which, from the standpoint of officers of the Society who often must travel long distances to these meetings, is appreciated.

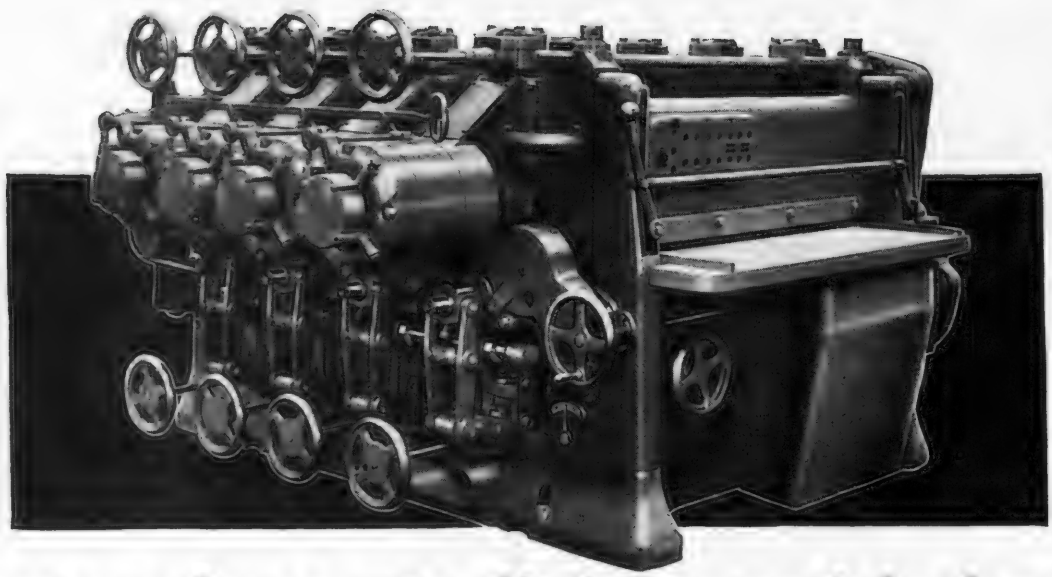
Another important Section meeting which I hope to attend is in Rockford, Ill., October 24–25, on the subject of woodworking machinery. I understand the Midwest Section is striving for an attendance in excess of 300 at this meeting.

In general, I note that all of the Sections have scheduled meetings on dates which do not conflict with those of adjacent Sections. For example, I note the Upper Mississippi Valley Section will meet October 16 at Wausau, Wis. eight days prior to the Rockford meeting. While I realize our Sections have already scheduled dates for this fall, I would like to suggest that in future seasons it might be possible for adjacent Sections to schedule meetings that do not conflict, yet may be contained within the same week. For example, one meeting early in the week and the other the latter part. In such cases, while the identity of the Section meetings remains separate, it may be possible for your national officers and others traveling long distances to attend both meetings in the same week.

One of the fine things about our Society is that every President whom I have known has always made a great effort to visit as many of the Sections as he possibly could during his term of office. I am convinced that these visits, tackling the "grass roots" problems of our Sections, is one of the underlying reasons for the effective strength of FPRS. It is important to keep the lines of communication in our Society open at all times between our 3,200 members on through the section organizations to the National Executive Board. Further efforts in arranging Section meetings to attract more national officers is a step in the right direction.

In all of this I would like to stress that our growing FOREST PRODUCTS JOURNAL and the splendid liaison between our Sections and our Regional Board Members remain the strongest links in our line of communication. I urge each of our members to relay his views and other pertinent information both through the JOURNAL and through our local officers.

RALPH H. BESCHER, *President*



Improved way to finish particle board

eliminates chip-tearout problems

Mills using Yates-American Double-Deck Sanders come up with performance figures that are eye-openers!

You must agree that we at Yates-American can be unbiased in discussing the merits of surfacers versus sanders in chip-core operations. After all, we make both types of machines.

We feel that Yates-American surfacers are the finest. But — it is our honest opinion that *any* surfacer has *limitations,* when it comes to finishing particle board.

We estimate that about 60% of the end-use requirements for particle board call for a smooth finish you can get only from a *sander* — the Yates-American Double-Deck, in particular. Leading mills throughout the country back us up on that!

Does the Entire Job!

With the Yates Sander, finishing particle board is done in *one* operation:

It removes up to 3/16″ of stock (depending upon density of board) —at rates up to 50 feet per minute. It holds tolerances of less than ±.002″ over an entire sheet — *that we guarantee!*

There are no expensive carbide knives to joint, regrind, and reset. *No knife marks or chip tearout.*

Preferred by Leaders!

Leading companies like these have already purchased Yates-American Double-Deck Sanders:

American Parboard Corp.
Black Mountain, N. C.

Carolina Forest Products, Inc.
Wilmington, North Carolina

Columbia Hardbord Co.
Everett, Washington

Curtis Companies, Inc.
Clinton, Iowa

Elmon Gray Co.
Waverley, Virginia

Granite Board, Inc.
Goffstown, New Hampshire

Rock Island Millwork Co.
Rock Island, Illinois

Wabash Screen Door Co.
Minneapolis, Minnesota

Weyerhaeuser Timber Co.
North Bend, Oregon

Wynnewood Products Co.
Jacksonville, Texas

Don't you think a Yates Double-Deck Sander should figure in *your* particle board plans? Ask your nearby Yates-American man to make recommendations. Or write, wire, or phone us today at Beloit.

Yates-American
BELOIT, WISCONSIN

Branch Offices: Chicago, Illinois
High Point, North Carolina
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WMMA — Woodworking Machinery Manufacturers' Association

First with the *Finest* in woodworking machinery. Established in 1883

MATCHERS • MOULDERS • SURFACERS • RIPSAWS • RESAWS • SANDERS

AW-9

How's this for SANDPAPER LIFE!

Here are some figures that are hard to believe — we blinked once or twice ourselves, when we first saw them. But they're fact — actual performance figures supplied to us by two reputable companies, names you'd recognize at once.

Both mills are finishing particle board with a Yates-American Double-Deck Sander and are removing up to 3/16″ of stock. This is what they report on sandpaper life:

First two pairs of drums	1200 to 1500 hours
Third pair of drums	500 to 700 hours
Fourth pair of drums	150 to 200 hours

We repeat — these are not *our* figures. They've been furnished to us by *two different mills* and have been confirmed and re-confirmed.

FPRS Forest Products Journal

Vol. VI, No. 9
September, 1956

Greater Utilization of Material Obtained from New Machine[1]

WAYNE K. MURPHEY

Wood Technologist, Ohio Agricultural Experiment Station, Wooster, Ohio[2]

and

GILBERT D. SCHNEIDER

President, Schneider Machine Co., Lexington, Ohio

A machine has been developed which slices wood, without loss, into material suitable for use in rough products or which may be planed to finish sizes. The wood is sliced by a series of round knives mounted on mandrels and spaced by discs as wide as the desired lumber thickness. Although the knife action compresses the wood in the vicinity of the cut, this compressed material is removed in the planing process.

THE NEED FOR A METHOD of remanufacturing lumber from larger material and cants without waste has been apparent for a long time. In this remanufacturing process, sawdust may comprise as much as 50 per cent of the original material. The sawdust represents a loss of valuable lumber as well as presenting a disposal problem which adds to the cost of manufacture.

At the present economic level, these additional costs in several phases of wood products have put competitive materials in advantageous positions. For example, a manufacturer of small boats has been having difficulty obtaining white oak suitable for bending stock. A gang rip saw was used to break down the 4/4 oak of which approximately 25 per cent was lost as sawdust. With this problem in mind, G. D. Schneider has developed a machine which slices wood, without fines, into material suitable for rough products or which may be planed without any more loss of material than occurs when gang-ripped blanks are surfaced.

This machine slices wood in a series of round knives mounted on mandrels and spaced by discs which are as wide as the desired lumber thickness. A pair of these roller assemblies constitute a roller set which cuts the upper and lower surface of the wood and feeds the wood into the next pair of rollers. The knives of one mandrel slice the wood to a depth of approximately one-quarter inch, thus two sets of rollers are necessary to slice one-inch lumber. Thicker lumber may be sliced by the addition of roller sets.

To prevent cleavage ahead of the knives, a set of pressure plates are placed on the mandrel and spaced the same width as the lumber being remanufactured, thus the wood to be machined must be of a uniform size. Although the knife action compresses the wood in the vicinity of the cut, this compressed material is removed in the planing process.

The density of the wood regulates the depth of the knife cut. Adjustments can be made to increase or decrease the amount of material sliced by a roller set. Since the contact of the knives and the wood feeds the material, infeed and outfeed rolls are eliminated and all of the available power is used in driving the roller sets. The horsepower requirement has been calculated at 0.48 horsepower per cut. This lower horsepower requirement constitutes additional savings. The model shown in Fig. 1 uses a 15 h.p. electric motor with a V-belt drive with feed rates ranging from 20 to 80 lineal feet per minute.

The knives, which have been described as "round chisels," may be sharpened on the machine and adjustments may be made to sets to establish the desired depth of cut. When a series of knives, after repeated sharpenings, are too small to obtain this cut, they may be moved to the next roller. Thus a set of knives may be

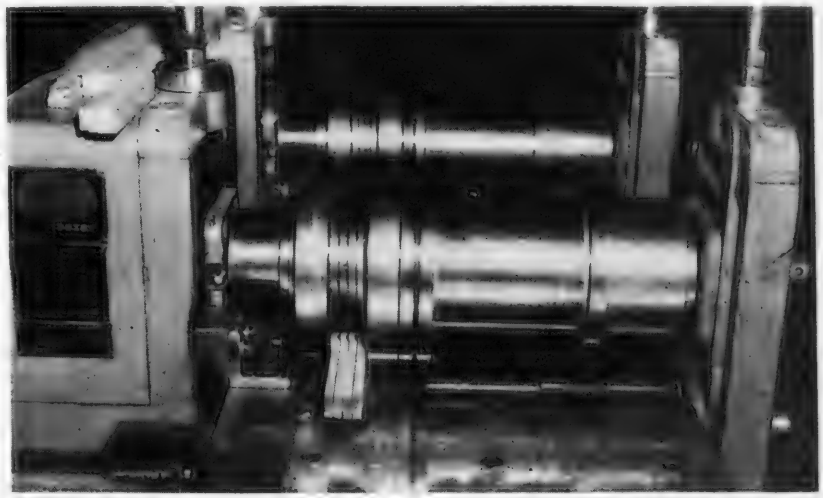


Fig. 1.—Piece of 1-inch kiln-dried basswood stock emerging from the slicer. The portion which has been sliced by the first set of knives is compressed by the second set. The photo shows the position of the pressure plates, spacers, and knives. If green material were being sliced, the crevice would not show as the fiber rebound is practically 100 per cent, thus closing the cut.

[1] Presented at Session IX, Wood Machining, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

[2] This does not constitute an endorsement of the machine by the Ohio Agricultural Experiment Station.

The Authors: W. K. Murphey holds B. S. and M. F. degrees in wood utilization from Pennsylvania State University, was formerly a member of the Technical Dept., Wood Preserving Division, Koppers Co., Inc.

Gilbert D. Schneider attended Capitol University, Columbus, Ohio, worked 11 years in wholesale hardware sales. He was an inspector with the Navy Inspection Service during World War II and in 1946 established a hardwood milling and dry kiln which is still in operation. In addition to the lumber business, since 1952 Mr. Schneider has developed the wood slicing machine described in this paper.

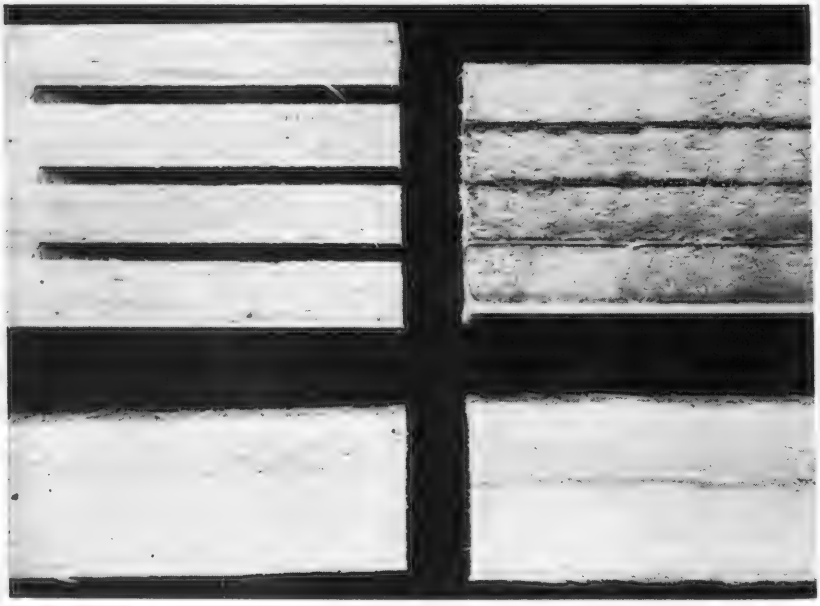


Fig. 2.—Material obtained from rip sawing (left) and slicing (right). Note the difference in the amount of stock required to obtain an equal number of pieces from the two methods (top) and the finish of both rough blanks (below).

reduced in diameter and still be usable, depending on the number of roller sets, the thickness of material, and the depth of cut of each knife.

Material tested on this machine ranged from kiln-dried hard maple to kiln-dried basswood. Although more testing is required to develop optimum depth of cut per knife for each species, a 1/4-inch cut per knife produced material acceptable for finish surfacing.

Raw Material Savings

In an application of the machine to the production of yardstick blanks, only 1/64 inch was required to be removed by sanding to produce finished blanks. In this application, seven 1/4-inch blanks were obtained by slicing, compared with five blanks previously obtained from a gang rip saw operation.

To illustrate the amount of savings realized by the introduction of this machine, one example may be cited. A manufacturer of hollow core doors was ripping surfaced 4/4 stock to 1/8-inch nominal thickness, using a gang rip saw with a 1/8-inch kerf. Thus 50 per cent of the surfaced material was being lost as fines. The use of the slicer doubled production.

Fig. 2 shows material obtained from slicing and rip sawing. Compare the amount of stock required to obtain an equal number of pieces from the two methods and the finish of both rough blanks. Notice the amount of compression caused by the knives. A similar amount of material will be removed in finishing the two blanks.

The saving of material is evident in Fig. 2. If the rip saw has a 3/16-inch kerf and the finished products are rough blanks 3/8-inch wide, eleven 3/8-inch sawn pieces could be remanufactured from a 6-inch nominal board, while sixteen 3/8-inch blanks could be sliced from the same board. This represents a considerable saving in raw material otherwise lost in saw kerf.

Besides the savings in material, the elimination of fines, and lower horsepower requirements, the slicer has several other advantages. These include: elimination of kickback since the wood is held firmly between the knives, low operating speeds which represent additional savings in reduced maintenance costs, and adaptability of the slicer to automation represents a potential just being realized in wood production. Noise is becoming a major factor in the production of wood products and, although no figures are available as to the number of decibels, the slicer has a decided advantage over the gang rip saw in that the only noise from the slicer comes from the motor and drive.

Its adaptability to many products and the saving of material make this machine a valuable contribution to increased utilization of our timber resources.

Fig. 3.—G. D. Schneider operating demonstration model of wood slicer.

Discussion

Frank Rebick (Ontario Hardwood Flooring Co.): Were any experiments conducted on hardwoods, such as oak?

Mr. Murphey: Yes, green white oak, kiln dry hard maple, kiln dry basswood, and other species have been sliced successfully.

Mr. Rebick: What was the maximum thickness?

Mr. Murphey: At the present time, the machine has been slicing 4/4 stock. However, there is no reason other than the strength of the knife which would restrict slicing thicker stock. Optimum depth of slice per knife has not yet been determined.

Peter Koch (Michigan State University): What was the r.p.m. of the cutting discs?

Mr. Schneider: The average r.p.m. of the cutting discs was half the speed in feet per minute of the feed. For example, 10 r.p.m. for 20 r.p.m. feed speed.

D. G. Faustino (Forest Products Research Institute, Philippines): What is the possibility of a like machine operating more or less on similar principles as the one indicated in the paper, for use as head rig in sawing logs of a diameter of 12 to 24 inches.

Mr. Schneider: It appears very likely that the machine can be enlarged to do the job right up to the head rig. That is, after the log is slabbed at the head rig, a variety of these machines could be used to break the cant into smaller sizes.

Maintenance of Quality in the Manufacture of Molded Plywood[1]

R. A. McKAY

Products Engineer, The Brunswick Balke Collender Co., Marion, Va.

The entire process for manufacture of molded school chair seat and back panels is covered, including strict purchase specifications, receiving inspection, storage and conditioning, flattening face stock by R. F. heat, presanding, molding, shaping, edge sanding, face polishing, and finishing. Solutions are given for specific problems in maintaining quality during production.

THE BRUNSWICK BALKE COLLENDER COMPANY entered the school furniture field three years ago with many decades of experience in the manufacture of quality and specialized woodwork. However, many of the problems encountered in the high volume production of molded plywood chair panels were unexpected. These problems became evident in production, in the testing laboratory, and in field tests. In combating this condition, the company developed an effective, thorough process that may be unequaled in the industry today.

Since the production of molded plywood panels with compound-curved surfaces is greatly dependent upon veneer quality, this process begins with a rigid and explicit set of purchase specifications. It continues through the manufacturing processes with the assistance of unique equipment and methods while under the continual observation of the Quality Control, Methods, and Engineering Departments. Current quality is evaluated on the basis of field reports while future qaulity is continually being determined in the testing laboratory.

Some of the problems which were overcome are:

1. Determining the quality of the veneer needed.
2. Securing reliable sources for this veneer, particularly the face stock.
3. Molding, machining, and sanding compound-curved panels.
4. Reduction of rejects such as split faces and machining errors.
5. Maintaining proper moisture content of veneer.
6. Minimizing face checks of panels after being placed in service.

In order to clearly present how some of the above problems were met and overcome, it is necessary to first briefly describe the product and the processes involved. The molded panels currently in production consist of five plies of 1/16-inch veneer. The faces, backs and crossbands are of hard maple and birch and the cores are sweet gum. Following hot pressing and post-cure conditioning, these multiple-curved panels are shaped, bored and countersunk for rivets, and face- and edge-sanded on a high-speed production line after which they are given a conveyor finish.

Purchase Specifications

In setting up the purchase specifications for the veneer to be used in the molded panels, standard grade rules were replaced with a strict group of specifications. This is particularly true with respect to the face grade; the other plies are purchased under specifications not too different from the standard crossband grade. This special face grade is the result of necessary requirements for the appearance and durability of the finished panel and production experience in attempting to fulfill those requirements. All shipments are inspected using statistical sampling methods before being formally received.

The following discussion of specifications applies specifically to face stock. The permissible species of maple and birch are listed by scientific names to remove possibilities of receiving less desirable species of those two genera. The acceptable species are sugar maple (*A. saccharum*), black maple (*A. negundo*), yellow birch (*B. leuta*) and sweet birch (*B. leuta.*) Because of the "white color" requirement, no heartwood is permitted and mineral streaks, stain, and other discolorations are restricted in size and quantity.

To minimize splitting as the faces are molded compoundly, they must be of one-piece stock, have no splits or checks, and must be reasonably tight cut and yet not excessively wavy. To minimize face checking in service so common to hard maple, the tight side must be marked, preferably at the, lathe, so that this side will be the exposed surface after molding. In order to minimize the sanding of this tight side, the stock must also be smoothly cut.

Surface measurements of all veneer have tolerances to eliminate clipping large quantities of veneer in order to keep the assemblies relatively the same size. The elimination of unnecessary handling naturally reduces damage to the faces. Thickness tolerances are also specified to insure sufficient face stock for sanding and to keep the assemblies approximately the same thickness for all the molds in each press. The moisture content specified is 6 to 10 per cent. And, last but not least, the supplier's method of packaging the veneer must be approved to insure against damage in transit and also to permit efficient handling and storage at the factory.

Reasons for Requirements

While some of the above requirements need no further explanation, these are some which the necessity for or the method of inspecting should be qualified. In forming a flat sheet of any material into a compound-curved surface, certain stresses are developed. If the material is sufficiently malleable, these stresses are relieved by compression or elongation as the case may be. Normal veneer, however, does not exhibit these characteristics as well as could be desired.

In molding the panels under discussion, the compressive stresses are either so small or are sufficiently relieved as to show no effects. This is not always the case with the tensile stresses, particularly when concentrated at the ends of the veneer. For this reason veneer for the faces must be of the higher strength species of

[1] Presented at Session XIV, Veneer and Plywood, FPRS Tenth National Meeting, June 4[illegible] in Asheville, N. C.

Author: R. A. McKay attended Virginia Polytechnic Institute, holds B. S. and M. S. degrees in wood technology from U. of Michigan. [illegible] was associated with the Wood Products [illegible] Texas Forest Service, and Bassett Furniture Co. before joining his present firm in 19[illegible]

Fig. 1.—Pre-sanding flat face veneer with veneer passing through precision sander from right to left.

maple and birch and must not only be sound but must be tight cut. In defining the degree of tightness (or looseness), the specifications limit lathe checks to 30 per cent of the thickness of the veneer to insure a certain amount of stock to absorb the tensile stresses, thus reducing their concentration and the resulting splits.

The depth of lathe checks, while being of utmost importance to the strength of the veneer, is rather difficult to thoroughly inspect. This specification serves primarily to make the suppliers strive to produce much tighter veneer than if there were no limitations. Looseness may be observed by bending a piece of veneer so that the loose side is outward and observing the size and number of checks. It is also readily observed by drawing a line on the loose side near the ends with a fountain pen or felt-tipped marking pencil. The depth of the checks is then indicated by the penetration of the ink into the checks. Veneer found to be excessively loose is down-graded to crossbands or back plies.

Moisture content is also a factor which influences the splitting of faces during molding. While wood becomes stronger as the moisture content is reduced, its elasticity is reduced. Thus, while striving for tight veneer and elasticity at the same time, it was found that the face veneer must have a moisture content of at least 6 per cent. The upper limit of 10 per cent was based upon the characteristics of the adhesive and the moisture content of the entire panel after molding as compared to the probable E. M. C. in which the panel will be used.

The veneer is stored under semi-controlled conditions and the processing and molding areas are humidified. Nevertheless, there are occasions when certain lots of apparently sound, tight veneer with the proper moisture content tend to split. This is generally overcome by adding moisture to the ends of the stock by dipping or sponging just prior to assembly. Increasing the moisture content so drastically in these areas must be performed with caution so as not to affect the adhesive causing a poor bond.

Precision Sanding

Normally the first production operation, with the exception of clipping which has been eliminated in this case, would be the molding or pressing of the panels. Thus sanding of the panel faces must be performed after they are contoured. Regardless of sanding precautions and smoothness of stock, "over-sanding" will occur at high portions of the panels. Over-sanding does not necessarily mean the complete removal of certain portions of the face, but rather removing enough stock from the tight, exposed side of the veneer to leave the lathe checks sufficiently close to the surface to cause checking in service. This in effect destroys all the quality obtained by many points of the purchase specifications.

Therefore, to maintain these quality advantages, it was logical that the problem of oversanding could only be solved by controlled sanding. Since this was impossible on the compound-curve surface, this controlled sanding had to be performed before molding while the veneer was still in the single ply state. Thus the molding of the panels was removed as the first production operation and was replaced by what is generally a final operation.

This pre-sanding is accomplished by means of a single drum precision sander (Fig. No. 1) developed for the leather industry. The drum is wrapped with fiber-backed 2/0 abrasive. With the limited thickness tolerances of the purchase specifications, this machine can be set a few thousandths of an inch under 1/16 of an inch and clean up all faces. Only the tight side of the face stock is sanded and, although the mark is removed, the sanded surface then indicates the tight side.

With reasonably flat veneer, the pre-sanding was the answer to the excessive belt sanding problem. However, when wavy stock was pre-sanded, oversanding again entered the picture. In order to perform accurately, the precision sander has an unpadded steel back-up drum beneath the abrasive wrapped steel sanding drum. With the spacing between these two drums set, the veneer, when passing through the sander, either moves against the back-up drum to produce uniform sanding or else that portion which does not flatten is excessively sanded. With wavy veneer, this results in long thin areas that were the high portions of the waves. These thin areas also present the problem of poor bonds due to insufficient pressure there.

In order to maintain the advantage of the pre-sanding operation and yet remove the disadvantages when wavy veneer was encountered, it became necessary to flatten the wavy stock. This is now successfully accomplished in an air-operated, five-opening R. F. press. The excessively wavy veneer is laid aside and when a sufficient quantity has accumulated it is flattened. Twenty sheets are placed in each opening. From four to five sheets, depending upon the general moisture content, are first sponged to prevent drying as the bundles are heated under pressure. The cycle ranges from five to ten minutes, depending upon the extent of the waviness (Fig. 2).

Following the flattening operation, the veneer is bulk piled and weighted. These stacks are not covered to protect the ends of the stock since the area is humidified. After cooling, this once wavy veneer is pre-sanded and then is ready for molding along with the face stock which by-passed the flattening operation.

Controlling Quality in Molding

The molding is performed in two three-opening hot presses with three sets of solid aluminum molds per platen. One press is set up for seat panels and the other for back panels. Each press has a separate crew and glue spreader. Nine assemblies are made using a craze-proof urea resin with minimum flour extension. The panels are cured in from 4–1/2 to 6 minutes, depending upon the contour, moisture content, and the particular catalyst in the glue mix.

After molding, the blanks are stacked on factory trucks on edge rather than flatwise to prevent distortion of the contours due to the weight accumulated in stacking. The blanks receive a minimum of 24 hours' conditioning before being shaped.

When the hot presses were installed, a thorough quality control program

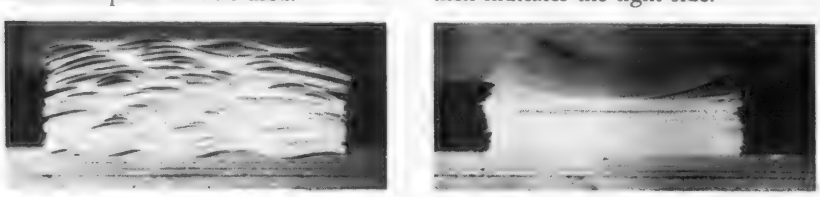


Fig. 2.—Bundle of 40 pieces of veneer before being flattened (left) and the same bundle after being flattened with pressure and R. F. heat.

was initiated to determine the quality of the glue bond, along with several other factors. This program called for the removal of one panel from each press at regular intervals. These panels were cut in two with half being marked for the standard plywood shear test the following day. The other half was cut into smaller pieces which, while still hot, were subjected to a desiccator test with the results being available in a matter of hours.

The severity of this soaking-under-vacuum test is such that a glue line failure does not necessarily mean that the same glue line would have failed during the standard Type II soak test after the adhesive had fully cured. However, failure during the desiccator test is still the signal to begin looking for some variable which is getting out of control. This would include bonding pressure, mold temperature, pressure time, moisture content of all veneer, and speed and age of the glue mix.

After several months of this extensive control work, operational specifications were set up and the testing reduced to periodic spot checks. The daily inspection reports from the machine lines are now the guide to how well the specifications are being carried out.

Special Machining Operations

Following the post-cure conditioning, the molded blanks enter the machining phase of production. There is a highly specialized, efficient machine line for both seats and backs.

The seat panel line begins with an automatic shaper with a center hold-down. The blanks are mounted on a contoured saddle while being shaped. The rivet holes are then bored in a specially designed automatic boring machine. When removed from the boring machine, the seat panels are placed in an automatic branding machine which burns the company name and code letters for the month produced on the underside.

The next operator countersinks the rivet holes, the depth of which is controlled by a stop that contacts the face of the panel.

The panels are then placed on a conveyor which takes them to either of two small, high speed, single belt sanders (Fig. No. 3). At this operation, the advantages of face veneer flattening and presanding are fully realized. This difficult, critical operation is now just a simple polishing operation in which finger prints, glue smears, and dents are removed. The sanding is now so light that with ordinary precautions excessive sanding has all but been eliminated.

—Photo courtesy Behr-Manning Co.

Fig. 3.—Polishing the face veneer on a seat panel. The operator is rocking the fixture with his left hand while polishing the front radius and feathering it into the back portion of the panel.

However, even polishing a panel with compound curves as found on the seats is no simple operation. The panels are placed on a fixture from which the comparatively flat portion is hand padded. With this complete, the panels are slipped back into another fixture which puts the sharply curved front portion of the panel upward. As this fixture is rocked slightly, the operator pads the front curve and feathers it into the area previously sanded.

These panels are returned to the conveyor from which they are removed for edge sanding. Here again a new idea was tried with much success. At this point, the edges of the panels are straight as cut by the shaper. They are transformed to a curved shape on high speed, vertical belt contour sanders (Fig. No. 4). As the belt moves against the contoured idler wheel, the panel is pressed against the belt, forcing it into the rounded grooves. As the seat is rotated against the belt, the square edges are removed and the edge of the panel becomes rounded.

Since the greatest removal of stock is from the top and bottom plies, this edge sanding is performed last. With the two rear corners of the seat curving upward, the faces at the edges in these two areas tend to become slightly oversanded as the operator is padding a lower area in the preceding sanding operation. Therefore, when this is followed by the edge sanding, this oversanded band is removed, leaving the maximum thickness of face veneer exposed.

Preparing Back Panels

The production line for the back panels resembles, to a great extent, the one described for the seats. It begins with an automatic shaper with a center hold-down. Here, however, there is no severe bend as found on the seats and therefore the back blanks are shaped completely around. The rivet

—Photo courtesy Behr-Manning Co.

Fig. 4.—Contour sanding the edge of a seat panel by pressing against the abrasive belt and forcing it into the grooved idler wheel and at the same time rotating the panel.

holes are bored in a specially designed automatic boring machine.

The hand holds are cut out on a router using a fixture to properly position the panel. Another operator countersinks the rivet holes with a drill press arrangement as found on the seat line. The same operator cuts a radius from the vertically cut hand hole by means of a small stationary router.

The panels are placed in an automatic branding machine for burning the code for the production period. The next operator removes the branded panels and sands the rounded edges of the hand holes on a small felt disc mounted on a spindle and wrapped with abrasive cloth.

The back panels are face polished on both sides on identical single belt sanders as on the seat line. Special fixtures enable the operator to position and restrain the panels while polishing. As with the seat panels, the edges are contour sanded as the last operation.

At the end of both production lines is an inspection station where all panels receive a thorough examination of contour, profile, rivet hole positioning, countersink depth, and sanding. They are also inspected for any possible machining defect, for splits and checks on face and back plies, openings on the edges due to splits in the inner plies, and glue line uniformity. Panels requiring rework or repair are taken to the proper station and any rejects are laid aside. Daily reports are issued covering all phases of this inspection. Thus this becomes a key operation in determining the quality and efficiency of all operations as far back as the loose veneer.

Panels passing this inspection are moved to the finishing room where they receive a hot sprayed conversion varnish finish. While stacked vertically, the edges are sprayed to insure sufficient finish on the highly absorbent edges. The panels are hung on the specially designed racks of an overhead conveyor. After the first coat and one pass through an oven, they are removed for sanding and edge spraying again. They are returned to the conveyor for the second coat of varnish. After emerging from the second oven, they are inspected individually once again.

Thus, after passing this final inspection, the panels are nearly perfect pieces of attractive, durable, molded plywood—the result of strict purchase specifications, new ideas in production and handling, and an active quality control program.

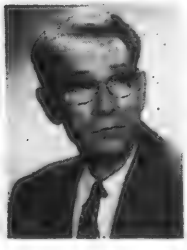
Discussion

Robert Chrismer (Poinsett Lumber & Mfg. Co.): Do you make five-ply birch or maple flat panels?

Mr. McKay: No, we do not.

Mr. Chrismer: How do you condition molded plywood after pressing?

Mr. McKay: Our veneer room is humidified to approximately 7½ per cent E.M.C. with all veneer being reasonably close to that moisture content at the time of pressing. The blanks, when removed from the press, are stacked on edge rather than flatwise to prevent distortion of the curves due to the load build-up of vertical stacks. Distortion of the curves is possible shortly after pressing since the panels are hot, moist, relatively limber, and the adhesive has not full cured. We attempt to hold panels for 24 hours before machining.



Insulating Fiberboard Roof Deck[1]

PAUL D. CLOSE

Technical Director, Simpson Logging Co., Shelton, Wash.

A recent product development involves the use of insulating fiberboard as the basic material in roof deck slabs. The product combines in one material the structural roof deck, insulation, finished ceiling, and in some instances the sound absorption. It is intended for open-beam construction and is particularly adapted to ranch-style houses, but has been used on many other types of buildings.

THE FIRST INSULATING BOARD in the United States was made by the M & O Paper Co., International Falls, Minn. (now the Insulite Division) in 1914, followed in 1921 by the Celotex Co. Today there are 14 domestic manufacturers of this type of product and several Canadian and foreign producers. Originally, only the 4 x 8-foot size structural insulating wallboard was produced, usually about ½-inch thick. Subsequently, other products for special purposes were developed including, for example, the lath which was used as a plaster base, wall sheathing, roof insulation and the factory painted interior boards of which there are three types, known as the building or interior board, tile, and plank.

A more recent product is the shingle backer used in conjunction with shingles or shakes and insulating board sheathing. One of the first special products made from the same basic material was the perforated acoustical tile, which is now being produced by most of the domestic insulating board manufacturers.

In 1946, the author proposed a product similar to the present insulating roof deck slab to the members of the Insulation Board Institute. As technical secretary of this organization at that time the author had been of the opinion that a product of this type would provide an efficient, attractive, and economical insulating roof deck for residences and other types of structures where exposed beam construction is acceptable. Furthermore, because of the tremendous roof areas involved and the multiple thicknesses of insulating board which would be required for a product of this type, it seemed apparent that there would be a substantial market for a product of this type if it proved successful. At that time, however, the Insulation Board Institute members did not indicate any apparent interest in a product of this type.

Shortly afterward, the writer joined the Simpson Logging Company of Seattle and Shelton, Wash., which was then building an insulating board plant and was soon to go into production. After manufacturing operations were started by Simpson, con-

[1] Presented at Session XI, Composition Board, FPRS Tenth National Meeting, June 4-7, 1956, in Asheville, N. C.

The Author: P. D. Close, mechanical engineering graduate of U. of Illinois, is author of two books on thermal and sound insulation. He was formerly associated with Johns-Manville Corp. and Celotex Corp., also served as technical secretary of American Society of Heating and Ventilating Engineers and the Insulation Board Institute.

Fig. 1.—Insulating roof deck slab used on a California residence.

Fig. 2.—Application of insulating roof deck slab.

sideration was given to the possibilities of making a product of this type. This culminated in a trial run of this type of board in the summer of 1948. The first two installations were made in Fallbrook, Calif. in late summer of 1948, and these jobs were followed soon after by others in the Phoenix, Ariz. area. Immediate enthusiastic approval of this product was given by architects, builders, and home owners.

Developments were slow at first because it was believed that a conservative policy was justified with this product because of the special structural requirements of this material, which were a considerable departure from previously accepted uses of fiber insulating board. Other structural products had been developed, such as the wall sheathing, but none which quite involved the requirements of this type of product. Nevertheless, time proved the structural worthiness of this roof deck and thus ultimately it became an accepted product in many areas.

The inevitable result of the experience of Simpson was that other manufacturers became interested in the possibilities of this product so that one by one the various producers of insulating board entered the market. Today most of the U. S. manufacturers of insulating board are, or soon expect to, make a product of this type.

Description

The insulating fiberboard roof deck products now on the market are 2 x 8 feet in size and are generally available in thicknesses of 1½-, 2- and 3-inch although certain types are not made in the 1½-inch thickness. These products have an interlocking, tongue and groove joint on the long edges and most of them have square edges on the end joint which fall over and are concealed by a beam. The products usually have a factory-applied white or off-white paint finish on the exposed ceiling surface. Natural or plain board is used for this lower or exposed layer of insulating board and asphalt-treated board is used for the remaining thicknesses. The product is generally made up of multiple ½-inch layers so that the 1½-, 2-, and 3-inch thicknesses consist of 3, 4, and 6 ½-inch layers respectively.

Certain manufacturers are producing a vapor barrier type product for use in cold climates. Some products also include provision for sealing either the end joints or the longitudinal interlocking joints against vapor leakage. In some cases the vapor barrier type is not produced in the 1½-inch thickness. Two types of vapor barriers are used: the sheet or membrane type whereby the vapor barrier is installed in back of the first layer of insulating board, and the asphalt coating type, the vapor barrier in the latter case being obtained by means of the asphalt use for lamination of the multiple ½-inch layers of insulating board.

An acoustical type of insulating roof deck is also available and it is reported that other manufacturers are planning to enter this field in the near future. The sound absorption of this type of product is provided by means of drilled perforations extending in most cases to the first glue line. This product is generally produced in the 2- and 3-inch thicknesses only.

Physical Properties

The insulating board from which the fiberboard roof deck is made complies with and generally exceeds to a considerable extent the requirements of Federal Specification LLL–F–321 b (with amendment) and other similar standards dealing with this product. These include Commercial Standard CS 42–49 and ASTM C208–55T and C209–55T entitled, Structural Insulating Board Made From Vegetable Fibers. In most cases, the class E or sheathing grade insulating board is used for the asphalt-treated board which comprises all but the bottom layer of this product, whereas the Class D or interior board is used for the bottom or exposed layer, the surface of which provides the interior ceiling finish.

As yet there are no accepted standards dealing with the fabricated roof deck although the technical committee of the Insulation Board Institute is working on such a standard in collaboration with the U. S. Forest Products Laboratory.

As the physical properties of proprietary products will vary to some extent and furthermore since there are no accepted test methods or standards, it is not possible to specify the physical properties of the various products except in general terms.

Insulating Value: The thermal conductivity of most of the insulating board products used in making the fiberboard roof deck will average about 0.36 Btu per hour per square foot per degree Fahrenheit per inch thickness, although some of the products may be somewhat higher. It is an established fact, however, that thermal conductivity test results by different laboratories will vary over a considerable range and until the results by the various laboratories are more nearly in agreement, this type of test should not be considered as exact. Thermal conductivity test results should therefore be regarded only as approximate at the present time.

Technically, the insulating fiberboard roof deck is non-homogenous because it is a laminated product consisting of two different types of board. The heat transfer through non-homo-

genous products is expressed in terms of conductances and the Insulation Board Institute has recommended the following conductance values for the three nominal thicknesses of the insulating fiberboard roof deck:

Nominal Thickness	Conductances*	U-Values**
1½"	0.24	0.19
2"	0.18	0.15
3"	0.12	0.107

*These conductances are in Btu per hour per square foot per degree Fahrenheit temperature differential for the thicknesses indicated.

**The U-values are for air-to-air and include the built-up roofing. The unit of heat transfer is the same as for the conductances.

The U-values in the right hand column are calculated from the conductances indicated in the center column and are based on factors in the ASHAE Guide.

The actual thicknesses of insulating board required to meet the conductances indicated may vary with different products. For example, if the board used in making the roof deck had a conductivity of 0.34 or 0.35, the actual theoretical thicknesses required would be slightly less than the nominal thicknesses specified, but of course the strength of the deck would be less for the lesser thickness. On the other hand, if the conductivity of the board used is greater than 0.36 — 0.38 or 0.40, for example—then greater thicknesses than the nominal thicknesses indicated above would be required.

Structural Properties: Inasmuch as the fiberboard insulating roof deck is a structural material, it must possess adequate strength for the purpose for which it is to be used. The strength and deflections of the deck will depend on the spans as well as the magnitude and type of loading. When this product was introduced it was established that the maximum practical framing centers under which this type of deck could be safely used were 16 times the thicknesses or 24 inches for the 1½-inch thickness, 32-inches for the 2-inch thickness, and 48-inches for the 3-inch thickness. Subsequent tests and field experience have verified the correctness of this rule.

Every product has its limitations and the fiberboard insulating roof deck is no exception. This product is not recommended where it will be subjected to severe usage or excessive loads or impact. It will perform satisfactorily when subjected to ordinary foot traffic and snow loads, as intended.

The principal structural tests for this product are the uniform loading, concentrated loading, and impact tests. A sag or deflection test is also recommended. Products of this type will generally sustain a maximum or ultimate uniform load well in excess of 300 pounds per square foot. A recommended requirement for exposed ceilings is that the deflection of the roof deck shall not exceed 1/240 of the span at the design load. This type of product generally conforms to this requirement at a design load of 50 pounds per square foot.

Concentrated loads applied through a 4- x 4-inch bearing plate are fairly representative of load distribution in actual practice. Tests are generally made at mid-span (midway between supports) and the maximum loads obtainable will depend on the point at which the load is applied, whether at a free edge or the center of a panel or over a joint of two adjoining panels.

The weakest point is generally at the edge of the panel and most products will sustain concentrated loads at this point ranging from 800 to 1200 pounds, depending on the thickness. The maximum concentrated load usually increases with the thickness of the roof deck at the recommended maximum framing centers. Maximum concentrated loads in excess of 2000 pounds have been obtained where the load was placed on the joints of two adjoining units and midway between supports.

Another test for this product is the measurement of the sag under a specified uniform load. The sag or deflection is measured immediately after the load is applied, after 48 hours just before the load is removed, and one hour after the load is removed.

The impact load test is made by dropping a sandbag from various heights to determine the maximum impact load strength. A 60-pound sandbag has generally been used for this purpose in the past, but a 10-pound bag dropped from a correspondingly greater height appears to be more suitable for this test. The bag is first dropped at a height of one foot and the height increased on successive drops until break through of the specimen by the bag occurs. The impact load strength is measured in foot-pounds.

Another appropriate test for this product is the accelerated aging test to determine the durability of this product.

All of the foregoing tests are of value to government agencies and code authorities to establish acceptance of this product and to architects and engineers for design purposes.

Fire Resistance: While the fiberboard roof deck is not fireproof, the greater thicknesses of this product increase the fire resistance over that obtained with a single ½-inch layer and at least one product has been rated as slow burning by a reputable testing laboratory.

Application of Roof Deck

The fiberboard insulating roof deck is intended for exposed beam construction. As stated previously, the beams are installed on maximum framing centers of 24, 32, and 48-inches respectively for the 1-½-, 2-, and 3-inch thicknesses.

The 2- x 8-foot roof deck is layed across and nailed directly to the wood beams, using common or galvanized nails of the proper size. Nailing specifications of the different manufacturers vary somewhat but most companies call for 10 penny (3-inch nails for the 1–½-inch roof deck, 16 penny (3–½-inch) for the 2-inch, and 30 penny (4–½-inch) for the 3-inch. Nails are usually spaced about 3–½-inches over the beams and up to 8-inches at the ridge and eaves and other places where nailing is required. The interlocking tongue and groove joints should be driven up tight whereas the end joints which fall on a beam are either butted or a small space left between them.

The top surface of the roof deck is covered with roofing. The most common type is the built-up roofing which consists of alternate layers of roofing felt and bitumen, either solid or strip mopped. Where coal tar pitch is used, the roof deck joints should be sealed against pitch drippage by means of a strip of roofing felt or by caulking.

Asphalt shingles may be applied directly to the roof deck by means of special nails, although this method of attachment is not generally recommended as yet, pending the results of tests now in progress. Where nails or other devices are driven into the deck, between the beams, the problem of condensation at the nails must be considered in cold climates. Wood shingles and other rigid types of roofing should preferably be applied to wood stripping which in turn should be nailed through to the beams. Lighting fixtures should always be attached to and supported by the beams. Conduit may be run in a chase routed out of the top of the beams.

In cold climates the vapor barrier type of insulating roof deck is recommended. The condensation problem is aggravated in cold climates by the fact that the built-up roofing, which is the type most commonly used, is in itself an excellent vapor barrier but is applied on the wrong side of the deck, that is, the cold side, whereas the vapor barrier should always be installed on the warm side. Theoretically, the vapor barrier should have a lower permeance than that of the roofing or any materials on the cold side of the deck, but this is difficult to accomplish where built-up roofing is used because of the high resistance to

Fig. 3.—Acoustical roof slab in a lodge recreation room in Phoenix, Ariz.

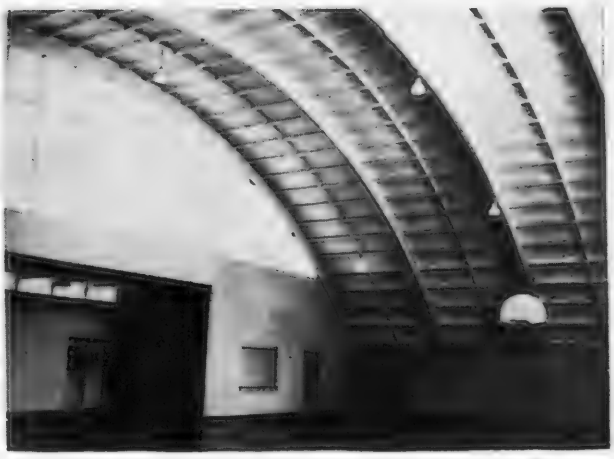


Fig. 4.—Acoustical roof slab applied to curved ceiling of school gymnasium in Washington.

vapor transmission of this type of roofing.

At any rate, it is important that proper consideration be given to the condensation problem where this product is used in cold climates. Paradoxically, the non-vapor barrier type roof deck has been used in cold climates without any apparent moisture problems. Most manufacturers do not recommend this product in any climate on buildings in which excessive humidities are likely to prevail.

Special Uses of Roof Deck

Where the roof deck is used on public buildings and other large structures in areas in which earthquakes and/or high winds occur, special methods of application are required to provide the proper degree of rigidity to the structure. If the roof does not have adequate stiffness and resistance to deflection, failure of the walls or the entire structure may occur. The roof deck must therefore be designed as a diaphragm to resist these stresses. This problem is being studied at the present time to determine the best and most economical methods of applying the fiberboard insulating roof deck to obtain maximum diaphragm strength.

Special uses of this product have been reported from time to time, some of which are not necessarily recommended. A few of these are as follows:

The fiberboard roof deck has been used as a base for a reinforced concrete roof slab which in turn in used as a promenade deck. The structural members must of course be of sufficient size to support the weight of the concrete slab.

The flexibility of the insulating fiberboard roof deck is such that it can be readily conformed to moderate curvatures. Several school gymnasiums have been designed using this type of construction.

Several instances have been reported where the fiberboard roof deck has been used for non-bearing partitions, supported only at the floor and ceiling. In one case, the white painted finish was applied at the factory to both surfaces, so that both sides of the partition were paint finished.

In at least one instance, the 1-½-inch roof deck was applied to the studs of a residence as a combined sheathing and exterior finish. The studs were installed on 24-inch centers and the outside surface was finished with two coats of an oil paint.

A special product of this type with hardboard laminated to one surface was used for flooring on a large temporary housing project. The 2-inch thickness roof deck was used and was installed on 24-inch centers. Except for the fact that the floor was slightly "springy", it served the purpose satisfactorily.

It is reported that this product has been used for concrete forms and left in place. Provision was made during application for anchoring the board to the concrete after it had set and the supporting wood framework removed.

In one instance, two layers of the 1-½-inch thick insulating roof deck were used, one on top of the joists in the conventional manner and the other on the bottom of the joists as a ceiling finish.

Summary and Conclusions

1. The insulating fiberboard roof deck combines in one material: (1) the roof deck, (2) thermal insulation, (3) ceiling and, in some instances, (4) the acoustical material.

2. The physical properties are such as to adapt this product to ordinary conditions of use as an insulating roof deck on spans of 16 times the thickness of the material.

3. Up to the present time this insulating roof deck has been used largely on residences of the type on which exposed beam construction is particularly acceptable, such as the popular ranch and contemporary types of construction. However, it has also been used on school buildings, churches, offices, warehouses, factories, and other structures.

4. On account of the extensive roof areas of residences and other types of structures on which this product may be used and because of the fact that multiple thicknesses of fiber insulating board are required, the potential quantities of wood and other fibers for manufacturing this product are tremendous.

5. As this product can be made from residue wood in many cases, the use of more wood in homes may be increased in some instances without cutting more trees.

6. The insulating type of fiberboard can be combined with plywood, veneers, and other types of composition boards to form a new composite material with still broader utilization possibilities.

7. This product and the various potential modifications thereof seems destined to be a major construction material which will be widely used on many types of structures.

Discussion

B. David Halpern (The Borden Co.): Is there a binder used in this insulating board? It is my understanding that ordinary Portland cement has been advocated for this use.

Mr. Close: No binders are used in the manufacture of insulating board. The strength is obtained by the matting or interlacing of the fibers during the board forming process.

W. J. Worth (National Homes Corp.): On a steep pitched roof is there a special technique or method of attaching it to the roof?

Mr. Close: The insulating roof deck slab is nailed to the beams in the usual

manner and asphalt shingles may be applied by means of special attachments which may be nailed through the shingles into the deck and have excellent holding power in the roof deck. A satisfactory and economical nail is the large headed ring-type nail. These and other types of nails or attachments are being investigated at the present time to determine whether they are likely to induce condensation under certain conditions.

J. B. Huffman (University of Florida): Is a preservative used in the manufacture of the insulating board? Such a treatment would seem advisable under some use conditions.

Mr. Close: Some manufacturers introduce a preservative into their insulating board for protection against rot and termites.

Equilibrium Moisture Content Relations and Drying Control in Superheated Steam Drying

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Psychrometric variables in superheated steam and superheated steam-air mixes are considered. Charts are presented which relate relative humidities, dry and wet bulb temperatures, equilibrium moisture contents of wood, and steam content of the drying atmosphere. Applications of superheated steam drying and methods of drying control are briefly discussed.

Introduction

SPECTACULAR CLAIMS have been made in recent years for high temperature drying and numerous makes of superheated steam kilns are now commercially available. These new units are often advertised as being fully automatic with consequent ease and simplicity of operation.

However, as other articles on this subject have shown (13, 16, 20); the use of superheated steam as a drying medium is not a recent idea. Superheated steam kilns were, in fact, operating on the west coast of the United States as early as 1908, and a "high velocity, low superheat" kiln was developed by Tiemann (19) during World War I. Although trouble seems to have been experienced with the earlier kilns, particularly with respect to uneven drying and excessive degrade, improved Tiemann kilns apparently operated successfully for the commercial drying of softwoods. These kilns did not incorporate fans, but forced circulation was achieved by steam jets. Eventually, however, they fell into disfavor due to poor economy in operation and excessive corrosion troubles.

During the next 25 years or so, the process seems to have been used sporadically for specific experimental purposes but has not been advocated for general seasoning use. Villiere (21) mentions the design of a superheated steam kiln by Gil in France just prior to World War II, but this type does not seem to have been developed for commercial drying.

The idea of high temperature drying was taken up again in the early 1940's by German engineers, under the pressure of war economy, with the aim of reducing drying times. Krischer (11) advocated its use on the basis of a theoretical study of timber drying, but his analysis did not take full account of the botanical structure of wood and was of limited value.

Fischer and Czepak (5) carried out a number of experiments on high temperature drying using small kilns with fan-driven circulation and heating the wood to 212° F. in a saturated atmosphere before starting the actual drying. They were, however, hampered by a lack of theoretical knowledge of the equilibrium moisture content (E.M.C.) relations of wood above 212° F. In fact, it was only after this aspect had been elucidated by a number of workers shortly after the war that important progress was made.

It is claimed, with some justification, that the absence of accurate knowledge of E.M.C. relations was responsible for the failure of some earlier types of superheated steam dryers. Part of the success of the more recent models is undoubtedly due to the fact that the theoretical basis of superheated steam drying and the principles of kiln operation above 212° F. are now known in greater detail. A summary of the fundamentals of high temperature drying has been given by Keylwerth (9).

However, it is important to realize that even though the theoretical basis is now even better known than previously, superheated steam drying does not provide a universal seasoning method. Although the process can be successfully used for a number of purposes, its applications are strictly limited.

Fundamental Concepts

Relative Humidity Above the Boiling Point of Water: The relative humidity (per cent) of a drying atmosphere, ϕ, is usually defined as

$$\phi = \frac{P}{P_o} \times 100$$

where P = partial pressure of water vapor in the atmosphere at T° F;

P_o = pressure of saturated water vapor at T° F;

T = dry bulb temperature.

If so defined, the concept of "relative humidity" may be extended to atmospheres of superheated steam and superheated steam-air mixes at temperatures above the boiling point of water. In this case P_o is, of course, greater than the ambient atmospheric pressure. Thus for all practical purposes, the "relative humidity" is a function only of the partial and saturation pressures of the water vapor present in the atmosphere. The accuracy of Dalton's Law of Partial Pressures is quite sufficient for most purposes encountered in the theory of timber drying atmospheres, and the relative humidity is therefore considered unaffected by the presence or absence of air or any other gas in the atmosphere.

Equilibrium Moisture Content (E.M.C.): A discussion of the hygroscopicity of wood in superheated steam was given as early as 1917 by Tiemann

[1] Numbers in parentheses refer to literature cited.

The Author: Walter G. Kauman received Diploma in Applied Physics from Royal Melbourne Technical College, B.S. in Physics from U. of Melbourne. He has been with Division of Forest Products, C. S. I. R. O., since 1948, is now Research Officer in the Seasoning Section.

(19), who realized that low superheat (i.e. high relative humidity) was essential to avoid drying degrade.

Koehler (10) presented E.M.C.-relative humidity graphs up to 212° F., and similar plots have been published by a number of workers.

Graf and Egner (6), in the course of investigations of properties of wood after drying at various temperatures, gave curves of E.M.C. for temperatures up to 239° F., but this aspect of their work seems to have escaped the attention of most other workers. Ten years later, Fischer and Czepak (5), were still in doubt whether an equilibrium moisture content did, in fact, exist above 212° F.

In the late 1940's, a number of investigators studied the subject of high temperature equilibrium moisture contents more or less simultaneously. Keylwerth (9) published an E.M.C. chart extrapolated to temperatures of about 260° F., and also gave some experimental measurements of moisture contents of beech and spruce samples at temperatures above 212° F., confirming the accuracy of extrapolation. The method of extrapolation, as explained in detail by Kroell (12), involves plotting lines of constant E.M.C. on a co-ordinate system of the logarithm of pressure versus the inverse of absolute temperature, and extending them into the region of high temperature.

About the same time, E.M.C. values for *E. regnans* F. Muell. and *Araucaria cunninghamii* Ait. in pure superheated steam were determined experimentally by Grumach (7), at the Division of Forest Products, C.S.I.R.O., Melbourne, for temperatures up to nearly 300° F. That extrapolated E.M.C. curves agree to within about 1 per cent with experimental values has also been shown by Lansell (14) during work on vapor drying. Fig. 1 shows the E.M.C. values for wood in pure superheated steam determined by various workers up to about 300° F. Slight differences in the extrapolated curves are due to uncertainty in the values on which the extrapolations are based.

Malmquist (15) has published results of measurements regarding hysteresis effects in moisture sorption isotherms above 212° F.; his conclusions are, however, tentative and have not yet been confirmed.

Percentage Steam Content: A useful concept in the discussion of high temperature seasoning is the "percentage steam content" (German: Heissdampfsaettigung) of the drying atmosphere, introduced by Sturany (18).

The "steam content" (per cent), C, of a drying atmosphere is defined as

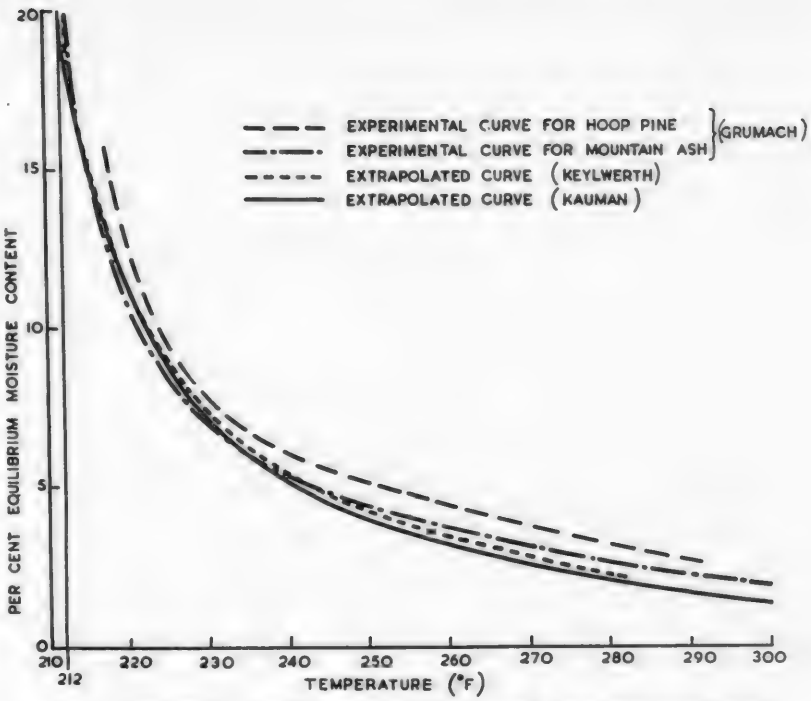

Fig. 1.—Equilibrium moisture content values for wood in pure superheated steam at normal atmospheric pressure as determined by various workers.

$$C = \frac{P}{P_A} \times 100$$

where P_A = total pressure of the drying atmosphere.

Constant steam content lines are thus simply lines of constant partial water vapor pressure, expressed as a percentage of atmospheric pressure; they are coincident with dew point lines.

To be consistent with accepted terminology, "steam content" lines should be termed "water vapor content lines" if extended below the boiling point of water at the operating pressure.

Maximum Relative Humidity and Maximum Equilibrium Moisture Content in Superheated Steam and Superheated Steam-air Mixes: The concept of "steam content" is particularly useful for the determination of changes occurring when an atmosphere of a given composition is heated above 212° F. A suitable chart is given in Fig. 2.

Consider, for instance, an atmosphere of pure saturated steam at 212° F.: the partial water vapor pressure equals normal atmospheric pressure and hence the steam content is 100 per cent. Now suppose this atmosphere is heated above 212° F. while maintaining normal atmospheric pressure (e.g. by means of a safety valve). The steam immediately becomes unsaturated, and the relative humidity decreases as shown by the 100 per cent steam content line. At 250° F., the relative humidity has fallen to 50 per cent; at 400° F., to 6 per cent. As long as the pressure remains at one atmosphere, steam above 212° F. is necessarily unsaturated, and the 100 per cent steam content line gives the greatest relative humidity which can exist at each temperature.

In the same way, if heating is commenced from 212° F. with an atmosphere of 90 per cent relative humidity instead of pure steam, and pressure again maintained at atmospheric, then the relative humidity at any temperature is found by following the 90 per cent steam content line. It also follows that the 80 per cent steam content line corresponds to 80 per cent relative humidity at 212° F., and so on.

The dew point of an atmosphere having a given composition is found by continuing the corresponding steam content (or water vapor content) line below 212° F. to the point where it cuts the vertical line of 100 per cent relative humidity at the extreme right of the chart. Thus, for instance, the dew point for 50 per cent steam content is 179° F.

It should be noted that the dry and wet bulb temperature lines at any specified steam (or water vapor) content meet at 100 per cent relative humidity at the temparture corresponding to the dew point.

Fig. 2 also shows E.M.C. values at constant relative humidities for temperatures up to 400° F., and wet bulb temperatures for the various steam content lines. The percentage equilibrium moisture content values are read on the horizontal axis, and wet bulb temperatures for any relative humidity on the vertical axis.

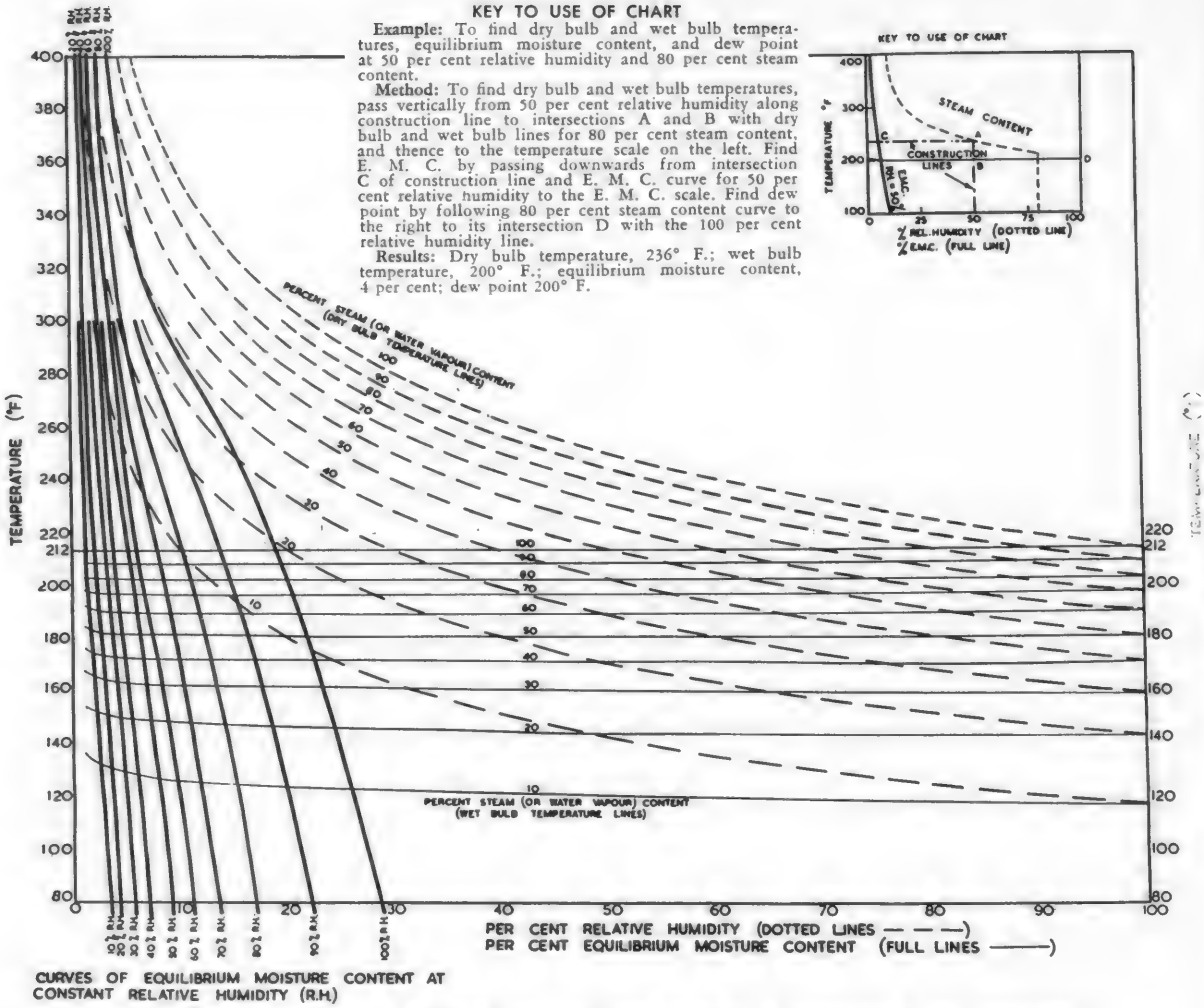
KEY TO USE OF CHART
Example: To find dry bulb and wet bulb temperatures, equilibrium moisture content, and dew point at 50 per cent relative humidity and 80 per cent steam content.
Method: To find dry bulb and wet bulb temperatures, pass vertically from 50 per cent relative humidity along construction line to intersections A and B with dry bulb and wet bulb lines for 80 per cent steam content, and thence to the temperature scale on the left. Find E. M. C. by passing downwards from intersection C of construction line and E. M. C. curve for 50 per cent relative humidity to the E. M. C. scale. Find dew point by following 80 per cent steam content curve to the right to its intersection D with the 100 per cent relative humidity line.
Results: Dry bulb temperature, 236° F.; wet bulb temperature, 200° F.; equilibrium moisture content, 4 per cent; dew point 200° F.
KEY TO USE OF CHART
STEAM CONTENT
CONSTRUCTION LINES
% REL. HUMIDITY (DOTTED LINE)
% E.M.C. (FULL LINE)
TEMPERATURE (°F)
PERCENT STEAM (OR WATER VAPOUR) CONTENT (DRY BULB TEMPERATURE LINES)
PERCENT STEAM (OR WATER VAPOUR) CONTENT (WET BULB TEMPERATURE LINES)
PER CENT RELATIVE HUMIDITY (DOTTED LINES — — —)
PER CENT EQUILIBRIUM MOISTURE CONTENT (FULL LINES ———)
CURVES OF EQUILIBRIUM MOISTURE CONTENT AT CONSTANT RELATIVE HUMIDITY (R.H.)

Fig. 2.—Equilibrium moisture content of wood and steam content of the atmosphere in pure superheated steam and superheated steam-air mixtures (at normal atmospheric pressure).

Since the relative humidity can never be greater than the value at 100 per cent steam content, it follows that the E.M.C. at any temperature above the boiling point of water must also have a maximum value which cannot be exceeded as long as the pressure remains constant.

If the total pressure is not maintained constant, the 100 per cent steam content line is displaced. Fig. 3 shows lines of constant E.M.C. plotted against dry bulb temperature and relative humidity. The dotted curves are 100 per cent steam content lines at various pressures; they indicate the upper limitation of the E.M.C. range in each case. It is generally considered that the total pressure does not significantly affect the dependence of E.M.C. on temperature and relative humidity; it merely limits the highest E.M.C. which may be reached at temperatures above the boiling point of water.

Fig. 3 shows that, for any given dry bulb temperature, the E.M.C. for wood can, as previously indicated, not be increased above the value at 100 per cent steam content. Thus, at 250° F. and atmospheric pressure, the highest equilibrium moisture content possible for wood is 4 per cent.

Control of Drying Conditions in Superheated Steam Kilns

Proper control of E.M.C. conditions is of paramount importance in any timber seasoning process. Conventional E.M.C. charts for wood are limited to temperatures below 212° F. and are thus of no use for controlling high temperature drying. Fig. 4 shows a new chart derived from Fig. 2 and specially designed to give relative humidities and E.M.C. values as functions of dry and wet bulb temperatures at normal atmospheric pressure, to a dry bulb temperature of 300° F. The chart also contains percentage steam content lines.

Drying Conditions at Normal Atmospheric Pressure: *Drying in Pure Superheated Steam.*—In a pure superheated steam atmosphere, the drying conditions can be identified by the intersection of the relative humidity and E.M.C. lines with the vertical 100 per cent steam content line at the extreme right of the chart in Fig. 4. For example, at a dry bulb temperature of 240° F., the relative humidity is 58 per cent and the E.M.C. is 5½ per cent. Since the wet bulb temperature for this atmosphere is always 212° F., the relative humidity and equilibrium moisture content are uniquely controlled by the dry bulb temperature, that is, by the degree of superheat of the steam. One thermometer is therefore sufficient for the control of drying conditions.

Superheated Steam-Air Mixes.—In the case of a superheated steam-air mix, the drying conditions are controlled by essentially the same procedure as at temperatures below 212° F. If the steam content in the drying atmosphere always remained constant, it would be possible to control relative humidity and E.M.C. by the dry bulb temperature alone. As this is not so, however, both dry bulb and wet bulb must be controlled to ensure uniformity of conditions throughout a drying run.

Consider, for example, an atmos-

phere of 50 per cent steam content at 250° F. dry bulb temperature. Fig. 4 shows that the wet bulb temperature is 180° F., the relative humidity about 25 per cent, and the E.M.C. 2 per cent.

Drying Conditions at Pressures Other than Normal Atmospheric: It is interesting to consider what happens if the total pressure is not maintained at normal atmospheric (30 in. mercury).

When operating at, for example, 2 atmospheres pressure (absolute), water boils at 249° F., and the 100 per cent steam content line in Fig. 2 is shifted bodily upwards by 37° F. The corresponding positions for the lines of lower steam contents would then have to be recalculated. The wet bulb temperature for an atmosphere of pure superheated steam at this pressure is, of course, 249° F.

For a given dry bulb temperature, a higher E.M.C. would therefore be possible than at normal atmospheric pressure (see Fig. 3). At 250° F. and 1 atmosphere pressure, for instance, the E.M.C. for 100 per cent steam content (the highest E.M.C. possible for this temperature and pressure) is about 4 per cent; for the same temperature at 2 atmospheres pressure, however, the E.M.C. would be about 15 per cent. Similarly, the relative humidity at 250° F. and normal atmospheric pressure would equal 50 per cent, but at 2 atmospheres it would be 98 per cent.

In order to adjust the chart in Fig. 4 for a pressure of 2 atmospheres, it would have to be extended to the right up to a wet bulb temperature of 249° F., with the steam content lines appropriately relocated.

On the other hand, consider operation at a location 7500 ft. above sea level. At this elevation the average atmospheric pressure is about 23 in. mercury (i.e. about 0.75 atm.), and water boils at 199° F. The 100 per cent steam content line in Fig. 2 is then displaced downwards by 13° F., and the chart in Fig. 4 terminates on the right at a wet bulb temperature of 199° F. For a given dry bulb temperature and steam content, the E.M.C. would then be lower than at normal atmospheric pressure. At 100 per cent steam content, its value at 250° F. would be only 3 per cent and at 220° F. about 6 per cent (compared with 4 per cent and 12 per cent respectively, at normal atmospheric pressure). The relative humidity at 250° F. and 100 per cent steam content at 7500 ft. would be 38 per cent; that is, 12 per cent less than at normal atmospheric pressure. This can be calculated simply as follows: the maximum vapor pressure at 7,500 feet elevation is 23 in. mercury. At 250° F. the maximum vapor pressure is 60.72 in. mercury; hence relative humidity equals 23/60.72 or about 38 per cent.

The maximum E.M.C.'s and relative humidities at various pressures from 0.5 to 5 atmospheres can be read from the chart in Fig. 3.

Drying Procedure

Usual practice in high temperature seasoning requires heating of the charge in a saturated atmosphere to prevent drying until the timber has become thoroughly heated to 212° F. When this has been achieved, the dry bulb temperature is increased to a

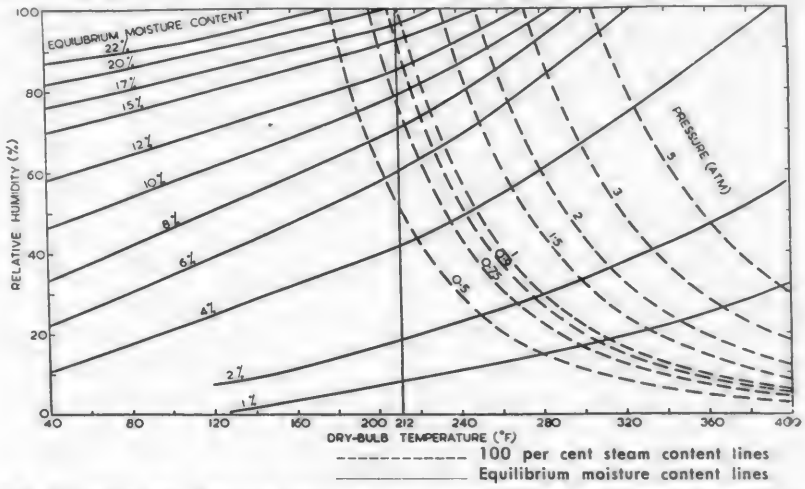

Fig. 3.—Equilibrium moisture content of wood and 100 per cent steam content lines at various total pressures.

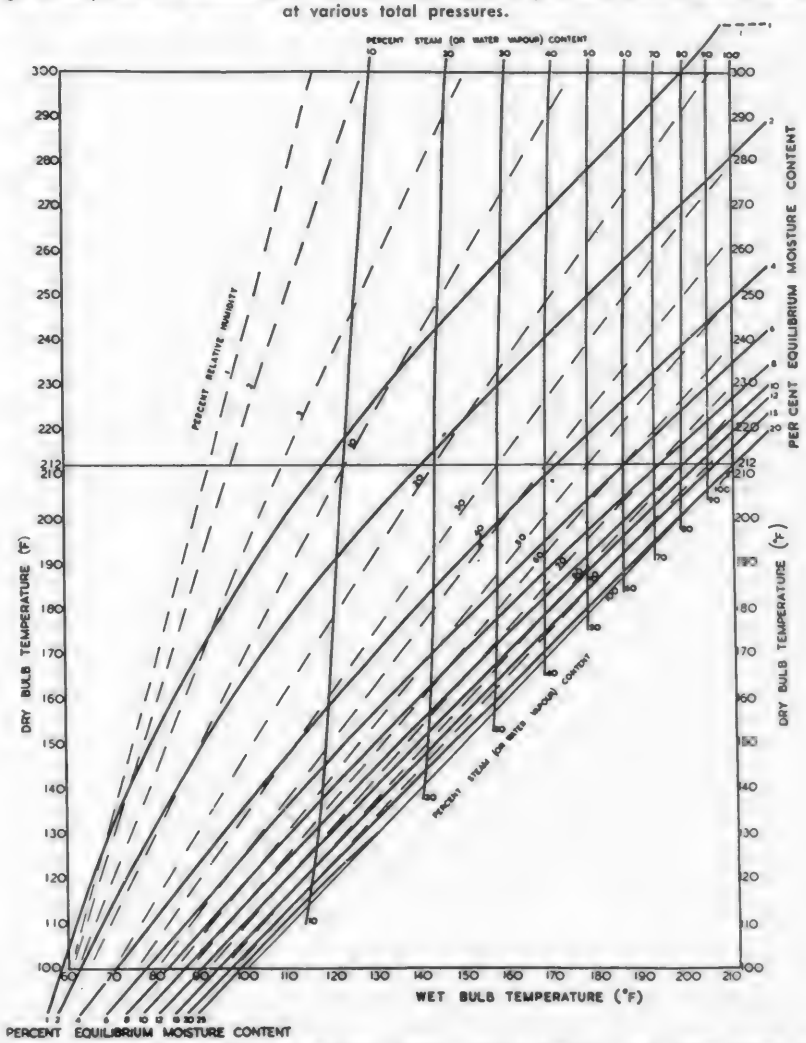
PERCENT STEAM (OR WATER VAPOUR) CONTENT
PERCENT RELATIVE HUMIDITY
PERCENT STEAM (OR WATER VAPOUR) CONTENT
DRY BULB TEMPERATURE (°F)
PER CENT EQUILIBRIUM MOISTURE CONTENT
DRY BULB TEMPERATURE (°F)
WET BULB TEMPERATURE (°F)
PERCENT EQUILIBRIUM MOISTURE CONTENT

Fig. 4.—Chart giving equilibrium moisture content, relative humidity, and steam content as functions of dry bulb and wet bulb temeprature (at normal atmospheric pressure).

value corresponding to the desired E.M.C. while maintaining 100 per cent steam content. After the timber has become partially dry, the E.M.C. may be lowered by further increasing the dry bulb temperature. More usually, however, the kiln vents are opened to admit some air and thus lower the wet bulb temperature while keeping the dry bulb temperature constant. At a somewhat later stage, the heaters are switched off and the heat stored in the timber charge is used to finish off the drying.

It is, of course, possible to introduce complete automation by means of time switches which may be set at the start of a drying run. The kiln can then run overnight without attendance. Such a procedure, however, would require a high degree of uniformity in the drying material to allow standardization of schedules and achievement of uniform final dried quality and moisture distribution.

Applications of Superheated Steam Seasoning

Egner (2, 3) and Ladell (13) have carried out detailed experiments with superheated steam drying. Discussions of the subject have also been published by Czepek (1) and Stevens (17). On a commercial basis, the process appears to be capable of drying softwoods and the more pervious and tolerant hardwoods in some 30 per cent of the time required for kiln drying in the traditional temperature range of 100°–180° F. In the case of the impervious hardwoods, however, severe checking and other degrade often occurs and temperatures have to be dropped to 180° F. or lower before anything like satisfactory quality is obtained.

The circulation in superheated steam kilns usually needs to be rapid to carry away the large quantities of moisture evaporated. Even so, the moisture distribution within boards and throughout the stack is often unsatisfactory unless appropriate conditioning periods are provided.

As far as is known to the author, no information is at present available on the application of superheated steam drying to highly collapsing timbers of the Australian "ash" eucalypt type. Scout tests carried out at the Division of Forest Products, C.S.I.R.O., on the superheated steam drying of karri *(E. diversicolor* F. Muell.), a species normally susceptible to only slight collapse, showed that at drying temperatures of 220° to 240° F., moderate to severe collapse developed in 1-in. boards. Backsawn material was found to split freely during drying, but quartersawn boards dried with little checking, though distorted and corrugated by collapse (Campbell 1955, unpublished data).

Superheated steam drying can be suitable for predrying softwoods prior to a preservation treatment where a severe moisture gradient would be no disadvantage. Furthermore, impervious or collapse susceptible hardwoods, though unsuitable for drying from the green condition, might be satisfactorily dried from a partly air dried condition (about 25 per cent).

Experiments on high temperature vapor drying of highly collapsing timbers *(E. regnans* F. Muell., *E. gigantea* Hook f., and others) [Elwood *et al* (4)] have shown wood temperature control at or below 150° F., in conjunction with a high vacuum, to be essential in order to avoid severe collapse and internal checking.

On the other hand, softwoods such as *Pinus radiata* D. Don, and very permeable hardwoods of 1-in. thickness (e.g. *Alstonia scholaris* R. Br.) could be vapor dried from the green condition in about 4 hours at temperatures of the order of 300° F. without visible seasoning degrade. Although in these experiments organic vapors were used as the drying medium, the temperature tolerance exhibited by different species might be indicative of their behavior during superheated steam drying.

The heat economy of high temperature drying in superheated steam is generally favorable, due to the inherent higher efficiency of water evaporation in superheated steam as compared with an atmosphere containing air [Ju Chin Chu *et al* (8)]. In addition, in high temperature units greater attention is usually given to insulation and vent design than is the case with kilns operating at lower temperatures.

Literature Cited

1. Czepek, R. 1950. Holztrocknung mit temperaturen ueber 100° C. Holz, Muenchen (Heft 12):246–247.
2. Egner, K. 1951. Holztrocknung bei temperaturen ueber 100° C. Holz als Roh- und Werkstoff 9 (3):84–97.
3. Egner, K. 1952. Heisstrocknung von Hoelzern. Holz Zentralblatt 78:745–752.
4. Ellwood, E. L., Gottstein, J. W., Kauman, W. G., and Wright, G. W. 1953. Vapour drying: A summary of research studies. Australian Forestry 17 (1):9–16.
5. Fischer, W. and Czepek, R. 1941. Die heisstrocknung von weichholz in elektrisch beheizten trockenraeumen. V.D.I. Fachausschuss fuer Holzfragen, Mitt. No. 30, p. 46–53.
6. Graf, O. and Egner, K. 1931. Versuche ueber die eigenschaften der hoelzer nach der trocknung. V.D.I., Fachausschuss fuer Holzfragen, Heft ½.
7. Grumach, M. 1951. The equilibrium moisture content of wood in superheated steam. C.S.I.R.O., Division of Forest Products, Internal Report: Project S. 17, Progress Report No. 5.
8. Ju Chin Chu, Lane, A. M., and Conklin, D. 1953. Evaporation of liquids into their superheated vapours. Ind. and Eng. Chem. 45 (7):1586–1591
9. Keylwerth, R. 1949. Grundlagen der hochtemperaturtrocknung des holzes. Holz Zentralblatt 75:953.
10. Koehler, A. 1926. Relation of moisture content and drying rate of wood to humidity of atmosphere. U. S. Dept. Agric., Forest Prod. Lab., Internal Report R. 509.
11. Krischer, O. 1941. Die physikalischen gesetzmaessigkeiten der feuchtigkeitsbewegung bei der holztrocknung. V.D.I., Fachausschuss fuer Holzfragen, Mitt. No. 30, pp. 34–45.
12. Kroell, K. 1951. Die bewegung der feuchtigkeit im nadelholz waehrend der trocknung bei temperaturen um 100° C. Holz als Roh- und Werkstoff 9:176–181, 216–224.
13. Ladell, J. L. 1954. High temperature kiln drying of Canadian woods. J. For. Prod. Res. Soc. IV(5):260.
14. Lansell, C. V. 1951. Personal communication of work carried out at the Oregon Forest Products Laboratory, Corvallis, Oregon.
15. Malmquist, L. 1953. Beobachtungen zur hygroskopischen hysterese von holz oberhalb 100° C. Holz als Roh- und Werkstoff 11:174–175.
16. Mathewson, J. S. 1954. High temperature drying: Its application to the drying of lumber. J. For. Prod. Res. Soc. IV(5):276.
17. Stevens, W. C. 1952. Timber drying in superheated steam. Timber and Plywood, Sept. 18.
18. Sturany, H. 1952. Trocknung im reinen heissdampf. Holz als Roh- und Werkstoff 10:358–362.
19. Tiemann, H. D. 1917. The kiln drying of lumber. Lippincott & Co., Philadelphia & London, pp. 47–51, and Chap. IX.
20. Tiemann, H. D. 1952. Recent development in transportable kilns. Southern Lumberman 185(2319):56–57.
21. Villiere, A. 1953. Nouvelles techniques de sechage artificiel. Rev. internat. du bois 20:195.

Estimating the Moisture Content of Lumber During the Drying Process[1]

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Information obtained by weighing units of stuck lumber at various times during the drying process has been evaluated and compared with information obtainable by conventional sampling techniques. Results are promising and indicate that weight data from an entire lot of lumber may provide a basis for estimating the moisture content of the lumber more accurately and more easily than is economically possible by other methods.

Introduction

EVERY IMPORTANT PROPERTY of lumber is affected by its moisture content and, for many uses, the range of acceptable moisture contents is quite narrow. This is particularly true in a number of uses where other materials are competing strongly with lumber. Lumber may have aesthetic and economic advantages but unless it gives satisfaction in use, it surely will lose out to competing materials—materials which may not possess many of lumber's advantages but which do not suffer from the disadvantages which are inherent in poorly dried lumber.

Rarely, if ever, is poor drying intentional. Rather, it usually is the result of overconfidence in the assumptions drawn from limited, and sometimes faulty, data on the moisture content of the lumber being dried. Consequently, an examination of the techniques used in estimating the moisture content of lumber during the drying process seems advisable.

Estimation of Moisture Content During Drying

Sample Boards: The estimation of the moisture content of lumber during the drying process frequently is based on data acquired by the periodic weighing of sample boards.

Sample boards are cut from the lumber to be dried, and the assumptions are made that they are representative of the lumber being dried, that the moisture content of each sample board is equal to the average of the moisture contents of the sections cut from its ends, and that the drying conditions affecting the sample boards are representative of the drying conditions affecting the lumber with which they are placed.

While the theory behind the use of sample boards is sound, the following factors introduce considerable variability into the data which they provide:

- Variation in moisture content within each board,
- Variation in moisture content between boards,
- Variation in drying rate, and
- Errors in weighings and computations.

Simple procedural safeguards will reduce the effect of errors to negligible proportions. Randomization and replication—reliance on the results obtained from a number of samples selected at random — are the best means of compensating for variability.

It is difficult to find definite information in the literature as to just how many sample boards should be used. Different references suggest from two to six sample boards per kiln charge. Statements regarding the number of sample boards used during air drying are even less definite. Perhaps most helpful is the suggestion that "the more difficult the drying problem, the greater the number of samples needed."

Table 1.—DATA ON REDWOOD SAMPLE BOARDS

Sample Board Number	Green Weight lbs./bd. ft.	Per cent Moisture Content		
		Green	Air Dry	Kiln Dry
1	5.51	181	45.3	6.2
2	6.31	182	36.3	6.6
3	6.02	134	34.4	8.2
4	5.25	161	33.6	6.3
5	5.30	176	55.2	8.2
6	6.20	131	37.9	7.9
7	5.96	130	24.7	7.4
8	5.53	252	50.5	10.2
9	6.17	165	41.2	10.2
10	5.65	184	25.0	7.8
11	5.55	172	50.6	9.9
12	5.70	177	66.2	14.0
$\bar{X}$	5.76	170	41.7	8.6
σ	0.359	32.7	12.4	2.21
$\sigma_{\bar{X}}$	0.104	9.4	3.6	0.64

Let's examine the use of sample boards as a means of estimating the moisture content of California redwood during the drying process, bearing in mind that redwood is characterized by wide variations in initial (green) moisture content and in drying characteristics and that this variability exists not only among different boards but within individual boards, To compensate in part for this variability, redwood lumber is segregated according to weight and drying characteristics before drying. Table 1 gives sample board information obtained in connection with the experimental drying of a kiln charge of heavy segregation redwood. It is representative of the many sets of sample data obtained during the operation of the California Redwood Association's experimental kiln.

The differences between the moisture contents of the various samples (dispersion) may not appear to be excessive, and the average ($\bar{X}$) moisture contents may reflect the condition of much of the lumber, but what degree of confidence may be placed in these indications? Assuming a roughly normal distribution of moisture contents, 16 per cent of the boards in the charge probably had a green moisture content in excess of 203 per cent ($\bar{X} + \sigma$), and 2 per cent probably had a green moisture content in excess of 235 per cent ($\bar{X} + 2\sigma$). Even if the distribution is only approximately normal, there is about one chance in six that the average moisture content of the charge was about 180 per cent ($\bar{X} + \sigma_{\bar{X}}$), and about one chance in 50 that the average moisture content was 189 per cent ($\bar{X} + 2\sigma_{\bar{X}}$) or higher. Similar uncertainties surround the other data in Table 1.

The formula for the standard deviation, a measure of the dispersion of individual measurements about the average, is:

$$\sigma = \sqrt{\frac{\Sigma (X - \bar{X})^2}{n - 1}}$$

[1] Presented at Session VII, Wood Drying, FPRS Tenth National Meeting, June 4-7, 1956, in Asheville, N. C.

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Table 2.—THE RELATIONSHIP BETWEEN THE NUMBER OF SAMPLES AND σ AND $\sigma_{\bar{x}}$ FOR THE GREEN, AIR DRY AND KILN DRY HEAVY SEGREGATION REDWOOD FROM WHICH THE SAMPLE DATA SHOWN IN TABLE 1 WERE OBTAINED

Number of Sample Boards	Per cent Moisture Content					
	Green		Air Dry		Kiln Dry	
	σ	$\sigma_{\bar{x}}$	σ	$\sigma_{\bar{x}}$	σ	$\sigma_{\bar{x}}$
2	44.3	31.3	16.8	11.9	3.00	2.12
6	34.3	24.5	13.0	5.3	2.27	0.94
12	32.8	9.5	12.4	3.6	2.21	0.64
25	32.0	6.4	12.1	2.4	2.16	0.43
50	31.6	4.7	11.9	1.7	2.14	0.30

where σ represents the standard deviation,

X represents the individual measurements,

$\bar{X}$ represents the average of the individual measurements,

n represents the number of individual measurements.

The formula for the standard error of the average is:

$$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$$

Since n appears in the denominator in each formula, the greater the number of individual measurements (samples), the greater the certainty with which the standard deviation (σ) is determined, and the more closely the average of the samples ($\bar{X}$) approaches the average of the lot from which the samples were drawn. This is indicated by decreasing values for the standard error of the average ($\sigma_{\bar{x}}$) and is illustrated by the data in Table 2.

It should be noted that σ and $\sigma_{\bar{x}}$ vary with the number of sample boards and that they are not affected by the number of boards in the lot from which the sample boards were taken.

The information contained in Table 2 may be used to help solve the problem of establishing the kiln schedule to be used in drying the lot of lumber from which the samples were obtained. Experience has shown that the moisture content distribution patterns found in green redwood and in partially air-dry redwood are nearly normal. When the distribution is normal, we know that only once in 400 times will the average moisture content of the lot differ from the average moisture content of the samples by more than three times the standard error of the average.

With information based on 12 samples, there is a high degree of assurance that the average moisture content of the lot is within 10.8 per cent (3 times 3.6 per cent) of the average moisture content of the samples. If six samples were used, the difference between the average moisture content of the lot and the average moisture content of the samples could be as much as 15.9 per cent while if only two samples were used, this difference could be as much as 38 per cent.

The foregoing data demonstrate the desirability of having a reasonably large number of samples when using the sample board method of estimating the moisture content of lumber during the drying process. However, since the labor and material required for their proper preparation and for their periodic weighing preclude the use of as many sample boards as might otherwise be desirable, there is considerable interest in finding other, and preferably non-destructive, methods of estimating the moistue content of lumber during the drying process.

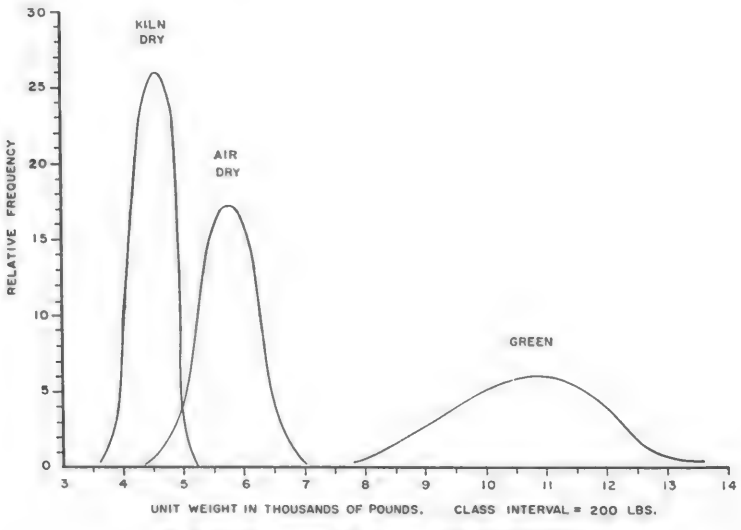

Fig. 2.—Frequency distribution of unit weights.

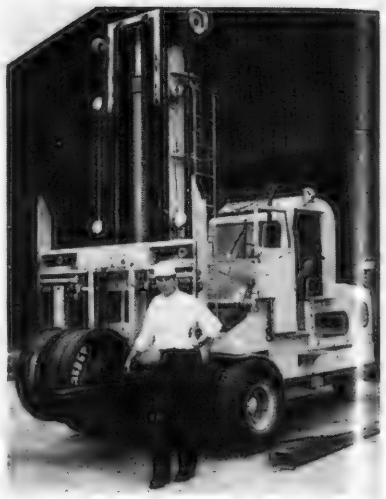

Fig. 1.—The accuracy of a weighing device attached to a fork-lift truck should be checked periodically by weighing a known weight.

Moisture Meters: Electric moisture meters may be used to advantage in estimating the moisture content of lumber which has dried to below the fiber saturation point. None of the commercially available meters appears to perform satisfactorily above the fiber saturation point. Perhaps some type of meter could be developed which would give moisture content readings based upon the attenuation or dispersion of a beam of radiant energy being passed through the wood. We are told that such meters are technically feasible, but the estimated cost of development and manufacture makes their feasibility a matter of scientific interest.

Lumber Weights: The shipping weight of lumber long has been used as a rough indication of moisture content. A practicable means was needed whereby lumber weight data could be made to yield more accurate moisture content information.

In many redwood mills, fork lift trucks are used to pile lumber in the air seasoning yards, to load lumber for kiln drying, and to unload the kilns. When a properly calibrated pressure gauge is attached to the hydraulic system which raises the forks, the units of lumber may be weighed at these times with but slight additional labor.

Such data recently have been collected and are plotted in Fig. 2, which shows the frequency distribution of the weights of 150 stucks unit of 1″ x 8″/12″ x 16′/20′ Heavy, Clear and A, Vertical Grain, redwood lumber. The weighings were made before and after air seasoning and after kiln drying. The pronounced increase in uniformity as drying progressed suggested the possibility that the weights of the stuck units might provide a

satisfactory basis for estimating the moisture content of the lumber during the drying process.

The data assembled to analyze this possibility are given in Table 3. The information on the specific gravity of redwood lumber is from Peck.[2] The other data were obtained from the Hammond Lumber Co., Samoa, Calif. At this company the practice is to pile 16-, 18-, and 20-foot lengths together for drying. Sometimes the lumber is sorted to width and sometimes random widths are piled together.

The weight data are based on 150 stuck units of random width 1″ x 8″/12″ Heavy, Clear and A, Vertical Grain redwood and 150 stuck units of 1″ x 8″ Heavy, Clear and A, Flat Grain redwood, a total of nearly 600,000 board feet. Data on width and thickness are based on a series of 45 measurements of each dimension. Since the variabilities of these dimensions are independent of board width, the results of the width and thickness measurements were applied to both the 1″ x 8″ and the 1″ x 8″/12″ lumber.

The results of calculations based on the data in Table 3 are given in Table 4. The formulas used are given in the appendix.

The boards cut from each log tend to remain together as they travel through the sawmill. As a consequence, the variability between the boards within each unit is less, in terms of the variability between units, than would be the case if the units were composed of boards selected at random. Also, during air drying the variation in the drying conditions which affect the different units is greater than the variation in the drying conditions which affect the boards within each unit.

These factors operate to make the variation in the moisture contents of the units a good indication of the variation to be expected in the moisture contents of the individual boards. This is illustrated by the data in Table 5.

The lumber was kiln dried according to predetermined schedules which were chosen on the basis of the air dry moisture contents indicated by the sample boards. The 1″ x 8″ was dried on a 10-day schedule and the 1″ x 8″/12″ was dried on a 12-day schedule.

Data on the kiln dry moisture content of the lumber is given in Table 6. These data indicate that there was less difference between the air dry moisture contents of these two lots of lumber than was indicated by the sample boards and that the moisture content data derived from the weights of the air dry units would have provided as good a basis for choosing kiln schedules as was provided by the sample boards, perhaps an even better basis.

[2] Peck, Edward C. 1933. Specific gravity and related properties of softwood lumber. Tech. Bull. 343. U. S. Dept. of Agriculture. Washington, D. C.

General Observations

The results of the foregoing analysis indicate that weight data may be used

Table 3.—EXPERIMENTAL DATA COLLECTED TO ASSIST IN EVALUATING THE POSSIBILITIES OF USING UNIT WEIGHTS AS A BASIS FOR ESTIMATING THE MOISTURE CONTENT OF LUMBER DURING THE DRYING PROCESS

Data	Number of Measurements	$\bar{X}$	σ	$\sigma_{\bar{x}}$
Specific Gravity of Redwood Lumber (green vol., oven-dry weight)	585	0.358	0.051	0.002
Volume per unit				
1″ x 8″ x 16′/20′	24	2011 bd. ft.	46.6 bd. ft.	9.5 bd. ft.
1″ x 8″/12″ x 16′/20′	24	1970 bd. ft.	71.7 bd. ft.	14.6 bd. ft.
Green dimensions of representative boards				
1″ x 8″ x 18′				
Length	—	218″	Not determined	
Width	45	8.20″	0.14″	0.02″
Thickness	45	1.06″	0.04″	0.006″
1″ x 10″ x 18′				
Length	—	218″	Not determined	
Width	45	10.20″	0.14″	0.02″
Thickness	45	1.06″	0.04″	0.006″
Weight of Stuck Units				
1″ x 8″ x 16′/20′				
Green	150	10,535 lb.	900 lb.	73.4 lb.
Air Dry	150	5,609 lb.	410 lb.	32.5 lb.
Kiln Dry	150	4,607 lb.	274 lb.	22.4 lb.
1″ x 8″/12″ x 16′/20′				
Green	150	10,531 lb.	1,230 lb.	100 lb.
Air Dry	150	5,635 lb.	430 lb.	35.1 lb.
Kiln Dry	150	4,475 lb.	263 lb.	21.5 lb.
Weight of Stickers and Bolsters (per unit)	10	270 lb.	5 lb.	1.6 lb.
Moisture Content of Kiln Dry Lumber (by electric meter)				
1″ x 8″ x 16′/20′	202	6.8%	2.69%	0.19%
1″ x 8″/12″ x 16′/20′	240	5.3%	1.44%	0.09%

Table 4.—RESULTS OF CALCULATIONS BASED ON THE DATA IN TABLE 3

Calculated Information	$\bar{X}$	σ	$\sigma_{\bar{x}}$
Oven-Dry Weights of Units			
1″ x 8″ x 16′/20′	4,100 lb.	108 lb.	39.4 lb.
1″ x 8″/12″ x 16′/20′	3,994 lb.	144 lb.	44.7 lb.
Net Weights of Units			
1″ x 8″ x 16′/20′			
Green	10,265 lb.	900 lb.	73.4 lb.
Air Dry	5,339 lb.	410 lb.	32.5 lb.
Kiln Dry	4,337 lb.	274 lb.	22.4 lb.
1″ x 8″/12″ x 16′/20′			
Green	10,261 lb.	1,230 lb.	100 lb.
Air Dry	5,365 lb.	430 lb.	35.1 lb.
Kiln Dry	4,205 lb.	263 lb.	21.5 lb.
Moisture Contents of Units			
1″ x 8″ x 16′/20′			
Green	150%	15%	2%
Air Dry	30.2%	6.4%	0.3%
Kiln Dry	5.8%	3.8%	0.05%
1″ x 8″/12″ x 16′/20′			
Green	157%	21%	2%
Air Dry	34.4%	5.6%	0.4%
Kiln Dry	5.3%	2.7%	0.05%

Table 5.—COMPARISON OF MOISTURE CONTENT INFORMATION OBTAINED FROM SAMPLE BOARDS WITH MOISTURE CONTENT INFORMATION OBTAINED FROM UNIT WEIGHTS

Lumber	Moisture Content of High-Moisture-Content Slow-Drying Sample Boards	Probable Average Moisture Content of Wettest Units ($\bar{X}+3\sigma$)
1″ x 8″ x 16′/20′		
Green	174%	195%
Air Dry	50%	49%
1″ x 8″/12″ x 16′/20′		
Green	210%	208%
Air Dry	70%	51%

Table 6.—COMPARISON OF MOISTURE CONTENT INFORMATION OBTAINED BY ELECTRIC MOISTURE METER WITH MOISTURE CONTENT INFORMATION OBTAINED FROM UNIT WEIGHTS

Lumber	Moisture Content of Individual Boards by Moisture Meter		Moisture Content of Units From Unit Weight Data	
	$\bar{X}$	σ	$\bar{X}$	σ
1″ x 8″ x 16′/20′				
Kiln Dry	6.8%	2.69%	5.8%	3.8%
1″ x 8″/12″ x 16′/20′				
Kiln Dry	5.3%	1.44%	5.3%	2.7%

as a basis for making reliable estimates of the moisture content of lumber and that the degree of reliability of the estimates may be predicted with good accuracy. Since weight data may be collected with but little additional effort during the normal activities incident to the drying operation, it well may be used as a basis for controlling drying. When used for this purpose, proper allowances should be made for the factors, other than moisture content, which affect weight.

The biggest single cause of variation in the data just analyzed was variation in the board foot volume of the units. This could be reduced by changing the piling practices.

A broader base for the information on the relationship between board foot tally and oven-dry weight could be obtained by selecting, at random, 1000 boards and drying them according to a schedule that included an exceptionally long equalization period. After drying and weighing, all the boards should be metered, and enough oven samples taken to provide a good check on the meter. This procedure would permit the calculation of oven-dry weights that should be more closely applicable than those calculated from board dimensions and the specific gravity of the species, as was done in this analysis.

Summary

Information obtained by weighing units of stuck lumber at various times during the drying process has been evaluated and compared with the information usually obtained by conventional techniques. While the work reported represents only an initial and limited exploration of the information obtainable from unit weights, the results are both promising and intriguing and indicate that weight data obtained from an entire lot of lumber may provide a basis for estimating the moisture content of the lumber more accurately and more easily than is economically possible by the limited sampling associated with methods used in the past, or by possible new methods that have been considered.

Acknowledgment

The assistance of A. F. Peterson, Hammond Lumber Co., and Gregory M. J. Lambert, California Redwood Association, in gathering basic data is gratefully acknowledged.

Appendix

Formulas used: The concept of representative boards (bd. in the formulas) was used to facilitate calculations.

$$\bar{X}\text{ cu. ft./bd.} = \frac{(\bar{X}\text{length})\ (\bar{X}\text{width})\ (\bar{X}\text{thickness})}{1728}$$

$$\bar{X}\text{ bd./unit} = \frac{\bar{X}\text{ bd. ft./unit}}{\text{bd. ft./bd.}}$$

$$\bar{X}\text{ cu. ft./unit} = (\bar{X}\text{ bd./unit})\ (\bar{X}\text{ cu. ft./bd})$$

$$\bar{X}\text{ OD wt./unit} = (\bar{X}\text{ cu. ft./unit})\ (\bar{X}\text{ specific gravity})\ (62.4)$$

$$\bar{X}\text{ net wt./unit} = (\bar{X}\text{ gross wt./unit}) - (\bar{X}\text{ wt. stickers \& bolsters})$$

$$\bar{X}\ \%\text{ M.C.} = \frac{(\bar{X}\text{ net wt./unit} - 1)\ (100)}{\bar{X}\text{ OD wt./unit}}$$

Where A and B are independent variables:

$$\sigma A + B = \sqrt{\sigma A^2 + \sigma B^2}\ ^*$$

$$\sigma A - B = \sqrt{\sigma A^2 + \sigma B^2}\ ^*$$

$$\sigma(A)(B) = \sqrt{(\bar{X}_A)^2(\sigma B)^2 + (\bar{X}_B)(\sigma_A)^2 + (\sigma_A)^2(\sigma_B)^2}$$

* Grant, E. L. 1952. Statistical quality control. McGraw-Hill Book Co., Inc., New York.

Assuming a direct relationship between the calculated oven-dry weights and the (observed) net weights of the units:

$$\sigma\ \%\text{ M.C.} = \left(\frac{\bar{X}\text{ net wt./unit} + \sigma\text{ net wt./unit}}{\bar{X}\text{OD wt./unit} + \sigma\text{OD wt./unit}} - \frac{\bar{X}\text{ net wt./unit}}{\bar{X}\text{OD wt./unit}}\right)(100)$$

In calculating the standard deviations of the moisture contents of the units, allowance was made for the standard deviation of the calculated oven-dry weights of the units. The effects of errors in weighing and of variation in the weights of stickers and bolsters were negligible.

Discussion

Norman C. Higgins (Michigan State University): How would the schedules be determined?

Mr. Pratt: A predetermined schedule would be used based on moisture content as determined by weight information.

Ray Rietz (U. S. Forest Products Laboratory): With the obtained standard deviation and weights of each charge, is it possible to program the drying by predetermined schedules?

Mr. Pratt: Yes. At present, predetermined schedules are used which are based on moisture content information derived from sample boards. The broader base obtained by weighing the large number of unit packages, which compose a kiln charge, offers a greater measure of accuracy and thus makes it possible to place greater reliance on the use of predetermined schedules.

Charles Latimer (Nickey Brothers): Do you feel that there will be any problem in maintaining the accuracy of the pressure gages due to rough roads.

Mr. Pratt: I don't think so. Experience has shown that the scales will last for several years. Periodic calibration will maintain the gages within the required accuracy limits.

Ray Rietz (U. W. Forest Products Lab): Do trucks used for transporting kiln packages have electronic weighing devices?

Mr. Pratt: I do not know of electronic weighing devices being used to weigh kiln packages in the redwood industry.

W. W. King (Tennessee Valley Authority): Do you feel that part of the between-package variation in moisture content is caused by the variable moisture content of the stickers? Do you think that the variable of sticker moisture content should be controlled?

Mr. Pratt: Yes, the weight of the stickers could introduce errors, if it were not taken into consideration. In this case, average sticker weights were deducted from average unit weights. Variations in sticker weights were found to have negligible effect on the variations in unit net-weights.

Charles Latimer: Do you feel that package weights can be used to control the variation in moisture content in air drying?

Mr. Pratt: Any use of weights to estimate the average moisture content of an individual package must be tempered with judgment as to the volume of lumber in the package, its average density, and other factors.

Dick Petersen: (St. Paul and Tacoma Lumber Co.): Why did you use board foot tally rather than cubic foot

measurement in determining the wood volume per unit?

Mr. Pratt: Because board foot tally is the most readily available measure of unit volume. The board foot tally was converted to cubic measurement in the calculations.

Roy Carter (N. C. State College): What is the fundamental cause of abnormal moisture content?

Mr. Pratt: I cannot account for the wide variation in moisture content found in California redwood. We recognize this variation and allow for it in drying.

Longitudinal Shear in Wooden Beams[1]

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A study of the relationship between longitudinal shear strength and block shear strength in southern pine beams and how these values may differ between laminated and solid beams and between radial grained and flat grained beams. Results indicate that the block shear test is not well suited for determining longitudinal shear strength.

Introduction

ONE OF THE PRIME PROBLEMS in designing short stiff wooden beams has been that of horizontal or longitudinal shear. This problem has been attributed many times to the occurrence of internal checks in large beams which reduce the shearing area and cause the beam to shear, but even in laminated beams where little checking is present there is danger of longitudinal shear. The strength of the wood necessary to resist this horizontal shear is usually computed from the apparent shear strength of the wood parallel to the grain as calculated from results of the standard block shear test. In recording standard shear tests it is customary to average the values of tangential and radial shear by testing half of the blocks each way (2).[2]

Materials and Methods

To measure the longitudinal shear strength in a beam it was first necessary to design a beam in which longitudinal shear would occur. Rectangular beams with various depth span ratios in the critical range were broken. No defect free rectangular beam was found in which longitudinal shear could be consistently obtained.

As a resut of the above experience, it was decided that the only suitable method for securing longitudinal shear in the beams would be to reduce the width of the beam at the neutral plane while leaving the full width at the top and bottom to contribute bending strength. This was done by running the beam through a shaper to obtain an I beam of the shape shown in Figs. 1 and 2. The triangular tips at each end helped support the beam on the bearing plates without contributing any extra shear resistance beyond the supports in the region of the neutral plane. The majority of beams of this design failed in longitudinal shear.

The test pieces were made of straight grained southern pine and were free of defects that might influence shear strength, such as checks, compression wood, pitch pockets, knots, and juvenile wood. Of the 44 test beams, 22 were laminated from nominal 1-inch lumber (11 from flat grained and 11 from radial grained 1 x 4's). The remaining 22 beams were from solid 2-inch lumber (11 were flat grained and 11 were radial grained). Except for these restrictions, the test material was randomly drawn from lumber which had been dried in

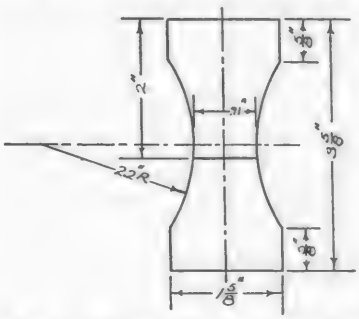

Fig. 2.—End view of a test beam showing the orientation of the cutout region with respect to the center lines. The horizontal line 2 inches from the top is the line where the wedge shaped bearing tips (Fig. 1) meet the main part of the beam.

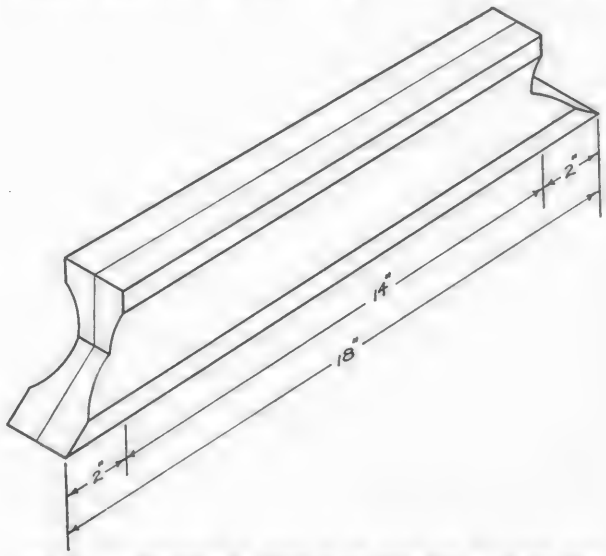

Fig. 1.—A laminated test beam of the type used in testing longitudinal shear. The drawing shows the form of the beam as well as the orientation of the glue line. The solid beams were of the same shape and size but were made of one piece with no glue line down the center.

[1] This paper was entered in the 1954 Wood and Wood Products Award competition while the author was an undergraduate in the Forestry Department, Alabama Polytechnic Institute, Auburn. Although not discussed in this study since it was not available in 1954, the reader's attention is called to an interesting paper by B. M. Radcliffe and S. K. Suddarth on the notched beam shear test for wood, Forest Products Journal, April 1955.

[2] Numbers in parenthesis refer to literature cited.

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Fig. 3.—Typical longitudinal shear failure in a radial grained beam (shear failure is tangent to the annual rings). This beam was typical of many of the beams which tended to fail somewhat below the neutral plane. It should be noted that only the wedge shaped bearing tips extend beyond the 14-inch span of the supports.

the A.P.I. Forestry Department kiln, and stored inside for at least nine months. The material averaged 10 per cent moisture and 0.53 specific gravity based on oven-dry weight and volume at test.

The pieces were designed and made according to Figs. 1 and 2. They were broken on a 14-inch span with care being taken to see that only the triangular tips extended past the supports (Fig. 3). The speed of loading was 0.2 inch per minute. For each beam, the maximum load was recorded and it was also noted whether the failure was due to static bending or longitudinal shear. For those beams which broke in bending rather than shear, the shear at maximum load was calculated and recorded as if it were

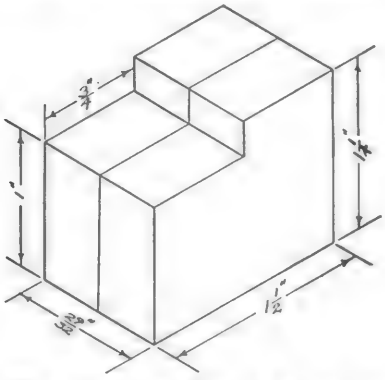

Fig. 4.—A shear block of the size and shape of those cut out of the test beams and used for block shear tests. Note that the shearing plane is at right angles to the glue line just as it is in a vertically laminated beam of the type used. The shear blocks from the solid beams were of the same form but with no glue line down the center. In both cases the plane of shear in the shear block was parallel to the neutral plane of the beam and hence tested shear in a plane parallel to the plane of maximum shear in the beam.

Table 1.—BEAM SHEAR AND BLOCK SHEAR FOR THE 44 SOUTHERN PINE TEST BEAMS EXPRESSED IN POUNDS PER SQUARE INCH. THE BEAM SHEAR WAS THE MAXIMUM LONGITUDINAL SHEARING STRESS IN THE BEAM PRIOR TO FAILURE. FROM EACH BEAM WAS CUT A SHEAR BLOCK WHICH FURNISHED THE CORRESPONDING BLOCK SHEAR STRESS PARALLEL TO THE GRAIN

	Fabrication Method			
	Laminated Beams		Solid Beams	
Plane of Shear	Beam shear	Block shear	Beam shear	Block shear
Radial shear	1690*	1300	1740*	1870
	1860*	2120	2150*	1650
	1040*	1520	1970*	990
	1230	1190	1770*	1870
	2250	1960	1710*	2030
	2210	1740	1910*	1980
	1980	1960	1690	880
	2100	920	1710	1150
	1980	1520	2120	1590
	2120	1580	1730	1260
	1560	1680	2120	1430
Averages	1820	1590	1875	1518
Tangential shear	1120*	1470	1430*	1210
	1520*	1580	1260	1320
	1540	1670	1480	1540
	1560	1710	1490	1810
	1730	2170	1770	1860
	1660	1850	1240	1150
	1390	1980	2100	1370
	1120	1740	1330	1260
	1470	1190	1220	1540
	1220	1300	1230	1240
	1730	980	1310	1540
Averages	1460	1604	1442	1440

*This beam failed in static bending. The shear reported is the shearing stress developed at maximum load.

maximum shear. The equation for horizontal shear was assumed to apply:

$$H = \frac{VQ}{It}$$

Where: H = Longitudinal shear stress
V = Vertical shear
Q = Statical moment
I = Moment of inertia
t = Thickness of the piece at the neutral plane

The values of maximum longitudinal shearing stress were calculated and recorded. The beams were then planed down to a thickness equal to the minimum web thickness and made into shear blocks as shown in Fig. 4.

Care was taken in making each block to see that no portion of the beam was used that had been split or damaged by the longitudinal shear test. Except for the non-standard size the blocks were tested using the standard block shear test (2). Each block was sheared in a plane paralled to the neutral plane of the beam from which it was obtained. The average block shear strength of all 44 blocks was 1,538 pounds per square inch which is quite comparable to the values usually reported for southern pine of this density.

For statistical purposes, each beam was considered to be a "plot" and since each beam was subjected to both longitudinal shear and block shear, the method of testing was analyzed as a "split plot" when an analysis of variance was made.

Discussion of Results

The laminated and the solid 2 x 4's showed no marked difference in shear strength nor did they respond in a significantly different manner to the other variables (Tables 1 and 2). The analysis of variance supports these facts

Table 2.—THE RELATIONSHIP OF FABRICATION METHOD (F), PLANE OF SHEAR (P), AND TESTING METHOD (T) TO THE PARALLEL-TO-GRAIN SHEAR STRENGTH OF SOUTHERN PINE WOOD AS SHOWN BY A SPLIT PLOT ANALYSIS OF VARIANCE. SEE TABLE 1 FOR DETAILED DATA

Source of variation	Degrees of freedom	Mean square	F
Total	87		
Main plots	43		
F	1	545	0.[illegible]
P	1	10,105	8.[illegible]**
F x P	1	372	0.[illegible]
Main plot error	40	1,180	
Split plots	44		
T	1	2,717	3.[illegible]†
F x T	1	1,016	1.[illegible]
P x T	1	7,291	9.1[illegible]**
F x P x T	1	5	.0[illegible]
Split plot error	40	799	

**Significant at the 1 per cent probability level.
†Between the 5 per cent and 10 per cent probability level.

by showing no significance for fabrication methods (F) or any of its interactions (Table 2). In view of this, the laminated and solid beams are assumed similar in the remainder of this discussion.

A visual inspection of the data (Table 1) suggests that block shear strength was similar for the two planes of shear but that longitudinal beam shear strength was greater in the radial than in the tangential plane. This differential response would seem to indicate that both testing method and plane of shear should be considered in the evaluation of shear strength in wood. The validity of these relationships is supported by the highly significant interaction (P x T) between plane of shear and testing methods shown by the analysis of variance (Table 2). This interaction explains the high significance for plane of shear (P) since a separate analysis of variance of the block shear values alone detected no significance for the slight superiority of radial plane values of block shear whereas a separate analysis of variance of longitudinal shear values alone yielded a high significance (variance ratio $F = 21.7$) for plane of shear (P). It would seem that this P x T interaction is also responsible for the near significance of the variance ratio ($F = 3.399$) for testing methods (T) since the supposed superiority of the longitudinal shear is not apparent when shear is in the tangential plane.

The fact that longitudinal shear did not exceed block shear in the tangential plane is perhaps a result of the method of testing employed. In a beam of some depth, the longitudinal shear can follow a plane of weakness quite readily and invariably the shear failure in southern pine occurs in the light springwood tissue. In the block shear specimens, the shear stress is concentrated at a region which may fall in either summerwood or springwood depending on which type of tissue happens to occur at the center of the block. Although this experiment was not designed to include this comparison, it seems quite possible that if the block specimens were purposely designed to concentrate the shear stress in the springwood, then block shear in the tangential plane might prove weaker than longitudinal shear in the tangential plane.

A correlation analysis failed to detect any significant correlation between the beam shear and the block shear values. For paired values of beam shear and block shear, neither the overall correlation coefficient nor any of the 4 coefficients within like fabrication methods and planes of shear even approached significance at the 5 per cent probability level. This suggests that the block shear test gave a rather poor indication of the longitudinal shear strength of a beam even when the shear block was cut from the same piece of wood as the beam.

Although the beams in this study were designed to fail in shear at the neutral plane well below the proportional limit of the beam, the failures did not always follow this pattern. As can be observed in Fig. 3, many of the beams tended to fail below the center even though the proportional limit had not been exceeded and theoretically the plane of maximum shear should have been at the center of the beam. In addition, a number of beams (Table 1) failed in static bending rather than shear even though in most cases the theoretical proportional limit had not been exceeded. For convenience in comparing these irregular beams, they have arbitrarily been placed together at the tops of their respective groupings. Had these beams not broken in bending, they presumably would have yielded somewhat higher shear stresses than those recorded. Such increased values would probably have served to increase the P x T interaction, the main effect of P (both already highly significant), and the main effect of T (perhaps making T significant at the 5 per cent level of probability.) Such a change in the analysis of variance would not change the major emphasis on the importance of the interaction of plane of shear and testing method.

The irregularities encountered in the manner of failure of these beams also call attention to the fact that the simple mathematical model of a beam does not always explain its behavior accurately.

Conclusions

For the southern pine beams used in this experiment, the following relationships were evident:

1. The laminated 2 x 4's showed no marked superiority to the solid 2 x 4's in shear strength.
2. The longitudinal shear strength in the radial plane was greater than the longitudinal shear strength in the tangential plane.
3. The block shear test gave a rather poor indication of the longitudinal shear strength of a beam even when cut from a portion of that beam.

Literature Cited

1. Snedecor, George W. 1940. Statistical methods. The Iowa State College Press. Ames, Iowa.
2. Wangaard, Frederick F. 1950. The mechanical properties of wood. John Wiley and Son, Inc. New York, New York.

A New Method for Long Term Preservation of Wood by Chemical Modification[1]

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A new process based on copper formate for the prolonged preservation of wood is described. In its final form in wood, the copper is converted to a copper-cellulose complex that resists removal by water, ammonia, and chelating agents. Laboratory and pilot plant application of the process are discussed and both laboratory and field tests are included. Comparative tests showing resistance to both marine and terrestrial attack are described.

Introduction

AT THE PRESENT TIME, wood is preserved for long periods by the use of creosote for the most part, and by the use of pentacholorphenol where "clean" wood is required. Wood also has been treated with inorganic salts and metalorgano compounds, including zinc chloride, chromates, fluorides, and chlorides of copper, mercury, and arsenic, Wolman salts, Greensalt, copperized chromated zinc chloride, copper naphthenate, zinc naphthenate, and others.

All inoragnic salts introduced into wood by water impregnation tend to be ultimately leached out by water and thus have relatively short periods of protection. Even materials like zinc meta-arsenite, that are claimed to be deposited colloidally in the fine structure of wood, eventually leach out. And materials like copper naphthenate, which are good fungicides, have other drawbacks. They are oily, have sharp, penetrating odors, sometimes leave the surface of the wood unpaintable, and are also leached away in time.

The inventor of this process, Dr. Bottoms, long ago observed that bits of wood which were cast up on a beach often contained copper nails. Undoubtedly, these were originally parts of larger timbers of which only the portion adjacent to the copper had survived. He reasoned that if the presence of copper metal preserved wood, then a copper compound firmly bound in the wood should give prolonged protection.

NCG Wood Preservative Process

Most of the inorganic fungicides and antiborer treatments described thus far apparently act as poisons. As such, it may be necessary that they have some degree of solubility to affect whatever its degree, ultimately results in the complete loss of the fungicide from the wood that it is protecting. The process that is the subject of this paper is based on copper formate. When the reaction between copper formate and wood is complete, the copper is believed to be involved in a cross-linking between adjacent cellulose molecules. The resulting product should be virtually permanently fixed in the wood by virtue of its composition.

Basically, the process involves the treatment of wood (or any cellulosic material) with a solution of certain organic copper compounds. For prolonged resistance to decay and to marine organisms, copper formate is outstanding. A maximum of 0.8% copper, based on the weight of the ovendry treated wood, is all that is required for prolonged protection. Lesser amounts of copper will also give good protection, and the threshold value is about 1.05% to 0.2%.

The process is relatively simple. Wood is subjected to a vacuum, dilute aqueous copper formate solution is sucked into the treating vessel, and then pressure is applied. The solution is drawn off and the impregned wood is autoclaved or otherwise heated to bind the copper with the cellulose. The visual effect of the heating is a change of the characteristic green color

[1] Presented at Session III, Wood Preservation, FPRS Tenth National Meeting, June 4-7, 1956, in Asheville, N. C.

[2] Contribution No. 157 from the Marine Laboratory, University of Miami, Coral Gables, Fla.

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R. R. Bottoms has been engaged in chemical engineering and research for the past 34 years. He was associate chemical engineer in U. S. Navy; chemical engineer, Helium Co.; Director of Research, Girdler Corp.; and Director of Research, Swann Co. before joining National Cylinder Gas Co. in 1941.

Edward Abrams holds B. S. from City College of New York, M. S. from George Washington U., Ph. D. from Georgetown U. He was associated with Bureau of Standards and Institute of Textile Technology before joining Southern Research Institute in 1950. He resigned in the summer of 1956 to join the Chemical Preservative Dept., National Cylinder Gas Co., Chicago, Ill.

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[3] NCG is a registered trademark of National Cylinder Gas Company, 840 North Michigan Ave., Chicago 11, Ill.

of the copper salt to that of weathered wood.

Copper formate applied to wood by impregnation alone leaches out readily. Moreover, the copper formate in the cellulose does not inhibit cellulolytic organisms. But, after autoclaving, the copper formate is converted to another copper compound. This compound does not readily leach out in water, in dilute ammonia, or in various chelating agents and, the wood is now decay-resistant. With regard to autoclaving, it should be emphasized that any form of heat will cause the conversion of copper formate to the copper-cellulose complex. However, autoclaving is a convenient method of applying heat to wood.

As the reaction which converts copper formate to the copper-cellulose takes place, another reaction appears to occur at the surface of the wood, and a small amount of cuprous oxide is formed, probably by simple thermal decomposition of some copper formate. The cuprous oxide can be readily removed with dilute ammonia. However, there is no reason to remove the cuprous oxide except for analytical purposes.

Marine Testing of Treated Wood

In the evaluation of a wood preservative process for marine application, two factors are of primary importance:

1. Presence of the preservative in wood must render the wood resistant to attack by marine borers.

2. The process must provide some mechanism, either mechanical or chemical, for preventing or retarding the loss of preservative as a result of the leaching action of sea water.

The following tests performed on wood treated by the NCG process were intended to ascertain whether the above-mentioned conditions are satisfied.

Resistance to Marine Borer Attack: Three groups of 1/8" x 2" x 6" wood panels[4] representing the following treatments were immersed in the ocean at Miami Beach:

Creosote, 5-20 lbs./cu. ft.	(60 panels)
NCG treated, 0.67% Cu	(6 panels)
Untreated	(2 panels)

A greater number of creosoted panels was used because they represent a range of concentrations, with a few panels treated at various concentrations throughout the range.

Fouling was scrubbed or scraped from the panels once or twice monthly, depending on the fouling settling rate. Results of previous tests using a similar procedure have shown that bi-monthly cleaning of the panels does not deter the progress of borers.

[4] A marine test panels intended for treatment the NCG process were made of clear D fir because of the inherent low resistance untreated fir to borer attack. Panels to be creoted were made of southern yellow Pine wood of uniform grain and density, because the ability of pine to retain relatively large ncentrations of creosote.

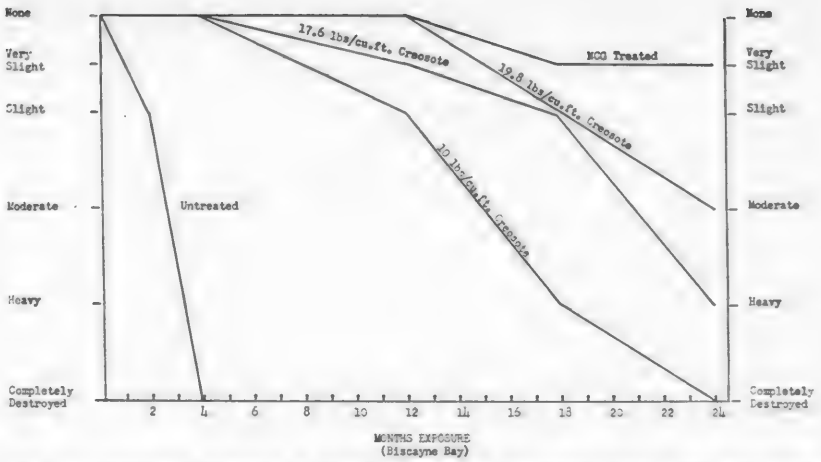

Fig. 1.—Comparative resistance to marine borer attack of creosote-treated wood and wood treated by the NCG chemical preservative process.

During the first four months of immersion, the untreated panels were completely destroyed by *Limnoria* and teredids. After one year of immersion, panels containing as much as 17.6 lbs. of creosote/cu.ft. were moderately damaged by borers, mostly *Limnoria*. The only damage sustained by the NCG treated panels consisted of a few minute pits, apparently the result of unsuccessful attempts by teredids to enter the wood.

After 18 months' immersion, all creosoted panels with retentions of less than 10 lbs./cu.ft. had been completely destroyed. All of the panels with higher retentions of creosote sustained moderate to heavy borer damage. A single *Teredo* was found in one of the NCG treated panels.

The NCG treated panels have been immersed for almost 2½ years to date, with no evidence of additional borer damage. Results of the experiment are illustrated graphically in Fig. 1.

It should be noted here that the intention of this experiment was to compare the *initial* borer resistances of NCG treated wood and creosoted wood. The results cannot be interpreted for the purpose of comparing the service lives of the two treatments because the principles governing the effectiveness of the treatments in terms of service life might be entirely different. For example, the permanence of creosote may depend upon replacement of dissolved preservative at the surface by diffusion from the "reservoir" of creosote inside the timber or pile. In the case of NCG treated wood, however, the preservative concentration at the surface is presumably maintained at a sufficient level by virtue of the bond which exists between copper and cellulose. It is therefore reasonable to expect that creosoted panels only 1/8 inch thick would be attacked after a relatively short period of exposure, because the panel is analagous to a 1/16 inch layer of creosoted wood on the surface of a timber or pile, with no reserve of creosote in the interior.

It may be concluded from these experiments, therefore, that the initial resistance to *Limnoria* and teredids of wood treated by the NCG process is comparable to that of wood treated with relatively heavy retentions of creosote.

Threshold Value of Copper Formate as a Marine Wood Preservative: Approximately 100 test panels (1/8" x 2" x 6") were treated with copper formate solution to give a fixed copper retention of 0.67% by weight of the treated wood. These were leached in 1 Molar sodium glycinate solution for periods of 1–26 days. The function of the buffered alkaline leaching solution is to hydrolyze the wood compcnents in a manner similar to, but at a greater rate than that which occurs on prolonged immersion in sea water. At the same time, the copper which dissolves as a result of hydrolysis of cellulose forms the highly soluble cupric glycinate complex ion, and continued solution of copper is permitted.

After the leaching treatment, the panels were immersed at Miami Beach. In spite of the severe pretreatment intended to remove most of the copper from some panels, no borer damage was observed during the first eight months of exposure. No steps had been taken to remove the excess leaching solution from the panels before exposure, so borer attack during the early part of the exposure period may have been prevented by the copper contained in the residual leaching solution.

During the ninth month of exposure, the surfaces of the panels which had been leached for the longest periods became deeply pitted from borer attack, but no live borers were found in the panels. As each panel became pitted it was removed from exposure and the portions of wood immediately surrounding the attacked areas were collected for copper analysis. The resulting copper concentration, 0.15% (±.01) is assumed to be the minimum that is necessary to prevent attack. Wood taken from panels completely free from attack by borers was also analyzed, and was found to contain from 0.2–0.5% copper.

Table 1.—RESISTANCE TO DECAY OF WOOD TREATED BY THE NCG PROCESS

Wood Species	Copper Content %	Decay* Wt Change, %
	Untreated Controls	
Yellow pine	----	—48.6
Douglas fir	----	—14.4
Tupelo gum	----	—70.7
Red oak	----	—68.2
	Treated Samples	
Yellow pine	0.48	0
Douglas fir	0.37	—0.8
Tupelo gum	1.47	—2.2
Red oak	0.67	—1.3

*Corrected for moisture content and preservative loss.

Rate of Leaching of Copper by Sea Water: A series of NCG treated panels (⅛" x 2" x 6") having a fixed copper concentration of 0.6% were immersed in clean, running sea water. Periodically the panels were transferred to individual leaching baths containing one liter of sea water. The rate of loss of copper from the panels by leaching was determined from analyses of the sea water before and after leaching for 3–7 days. The results are shown graphically in Fig. 2.

The concentration of copper in the treating solutions ordinarily is slightly in excess of that which will become fixed to cellulose. Most of this excess copper leaches from the wood during the early stages of immersion.

Table 2.—SUMMARY OF DECAY DATA BASED ON WEIGHT CHANGES AND PHYSICAL EXAMINATION

Wood Species		Decay Index* Decay Period, Months 1	2	3	4	6	9
Yellow pine	Treated	—	—	—	—	—	—
	Untreated	+	++	++	+++	++++	++++
Douglas fir	Treated	—	—	—	—	—	—
	Untreated	—	-	+	++	+++	+++
Tupelo gum	Treated	—	—	—	—	—	—
	Untreated	++	++	+++	+++	++++	++++
Red oak	Treated	—	—	—	—	—	—
	Untreated	+	++	++	++++	++++	++++

*Key to decay index:
— No decay; less than 5% weight loss and no physical evidence of attack.
+ Very slightly decayed; less than 5% weight loss, but with spotty surface attack evident.
++ Slightly decayed; 5–20% weight loss or definite weakening of fibers.
+++ Badly decayed; 20–40% weight loss or rupture of structure and severe strength loss.
++++ Very badly decayed; greater than 40% weight loss or nearly complete destruction of structure.

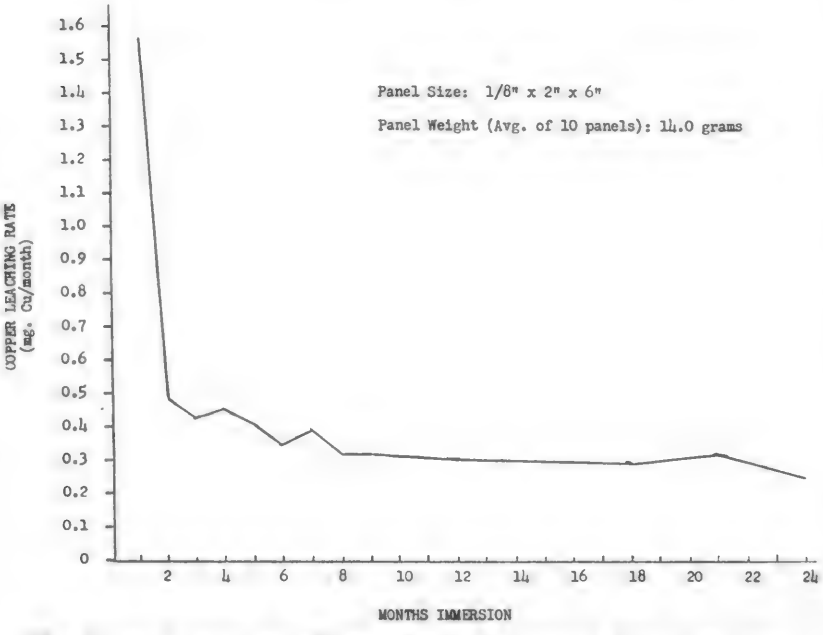

Fig. 2.—Loss of copper from NCG treated wood by the leaching action of sea water.

After 6–8 months of exposure, the leaching of copper from the panels used in this experiment attained what appears to be a constant rate of approximately 0.30 milligrams of copper/month. The average panel weight was 14.0 grams, so that the initial fixed copper content of each was approximately 94 mg. If the leaching of copper continues at a constant rate of 0.30 mg./month (3.6 mg./year), the wood may be expected to retain a copper concentration greater than the threshold value for 20 years. However, if the leaching process adheres to accepted solution and reaction rate principles, the amount of copper leaching at a given time will be a constant percentage of the residual copper concentration, and the service life may be expected to be considerably greater than 20 years.

Terrestrial Testing and Evaluation

Ideally, wood preservatives should be tested under actual conditions of use. However, it is obvious that such a procedure is not practical. A solution to this problem has been the development of accelerated tests that simulate the action of nature. Such a test is the widely used soil contact culture technique of Leutritz.[5]

Briefly, a number of cubical blocks of yellow pine, Douglas-fir, tupelo gum, and red oak were treated by the NCG wood preservative process as described above. One set of 40 blocks of each species of treated wood was selected for similarity of grain structure, and similar untreated blocks of each species from the same wood were selected as controls.

Preparation of Test Jars: Widemouthed jars were half filled with top soil of 6.3 pH and a moisture content of about 40%. Two feeder strips of the wood species to be tested were placed on the soil in each bottle and sterilized. When cool, the feeder strips were inoculated with the test fungus and the jars were then incubated at 27° C. and about 100% R. H. until the fungus growth had completely covered the feeder strips and had penetrated the soil. The fungi used for the tests were *Lentinus lepideus* for pine and fir, *Polyporous versicolor* for gum, and *Lenzites trabea* for oak.

Preparation of Test Samples: Treated and untreated test blocks were placed in each bottle over the appropriate fungus growth and again incubated. At each examination period, four treated and four untreated blocks of each wood species were removed

[5] Leutritz, John, Jr., 1946. A wood-soil contact culture technique for laboratory study of wood-destroying fungi, wood decay and wood preservation. Bell System Tech. J. 25 (1): 102-135.

from the test jars. The blocks were examined visually for evidence of fungal attack, and weight losses were determined.

Discussion of Results: Table 1 gives the results of the soil-block test after nine months of exposure. It is seen that the untreated controls have lost considerable weight. The Douglas-fir lost only 14.4% of its weight, whereas the tupelo gum lost 70.7% of its weight. On the other hand, all treated samples lost less than 2.5% of their weight (which was probably within the limits of experimental error of the tests) during the nine months of exposure and were completely free of growth of organisms.

In Table 2 a summary of the decay data by months is given. The method of rating is similar to one used by the U. S. Forest Products Laboratory[6]. Untreated tupelo gum was least resistant to decay, and Douglas-fir was most resistant, without preservative. With the NCG preservative treatment, all species resisted decay about equally. This can be seen graphically in Fig. 3.

Determination of Threshold Value of Copper Formate in Southern Pine for Soil Burial

Southern pine test blocks were treated with four concentrations of copper formate solution to give copper retentions ranging downward from 0.2% copper. Treated blocks and untreated controls were exposed in test jars, inoculated with *Lentinus lepideus* as described above, and were incubated for periods of two, four and six months. After six months, the untreated blocks had lost 58.2% of their original weight as compared to 3.1% weight loss for the blocks that contained 0.2% copper. Blocks with less than 0.2% copper lost an appreciable amount of weight. Below about 0.1% copper, the decay of the blocks approached that of the untreated controls.

A comparison of the results from Table 3 with those in Table 1 shows a similar trend in per cent decay for comparable copper retentions. While 0.2% copper gave relatively good protection over the six months' decay period, the decay is higher than values reported in Table 1. It is concluded that 0.2% copper retention in southern pine is the minimum for prolonged protection in contact with soil. A higher value of about 0.25% copper would allow for variations in treatment and in quality of wood. This threshold value for terrestrial protection is in the same range as discussed previously for marine uses.

Pilot Plant Treatment of Ties, Poles, and Lumber

In view of the satisfactory results obtained with small wood samples treated by the NCG preservative process, a pilot plant treatment of large wood samples was undertaken. Southern pine poles and 2 x 4's, and cross ties of red gum, American elm, red oak, white oak, and Southern pine were treated in a large wood treating cylinder by the following full-cell process.

1. Preliminary vacuum period, 28–29 in. mercury 30 min.
2. Cylinder filled with an 0.8% aqueous solution of copper formate while maintaining vacuum.

Table 3.—RESULTS OF DECAY TEST ON PINE BLOCKS TREATED WITH NOMINAL CONCENTRATION OF COPPER FORMATE

Wood Sample	Copper Content %	Decay, % 2 Months	4 Months	6 Months
Untreated control	0	32.4	52.2	58.2
1	0.02	20.2	48.7	54.8
2	0.05	7.5	16.1	55.8
3	0.09	0.1	16.6	18.4
4	0.20	0	0.9	3.1

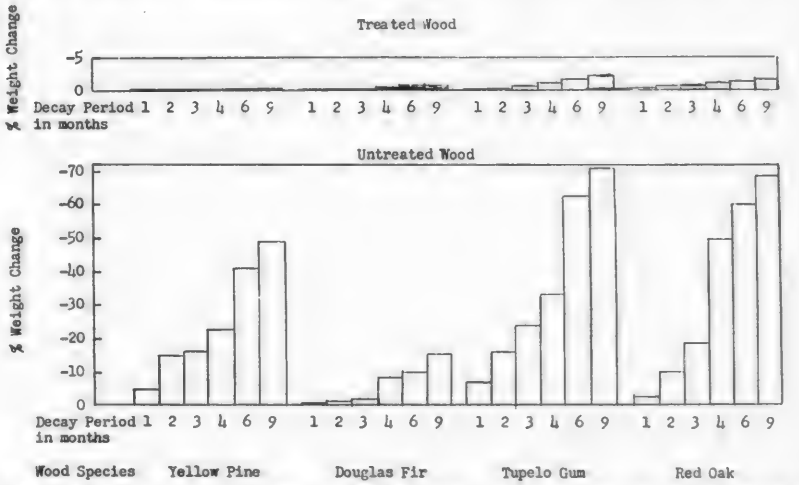
Treated Wood
% Weight Change
-5
0
Decay Period 1 2 3 4 6 9 1 2 3 4 6 9 1 2 3 4 6 9 1 2 3 4 6 9
in months
Untreated Wood
% Weight Change
-70
-60
-50
-40
-30
-20
-10
0
Decay Period 1 2 3 4 6 9 1 2 3 4 6 9 1 2 3 4 6 9 1 2 3 4 6 9
in months
Wood Species Yellow Pine Douglas Fir Tupelo Gum Red Oak

Fig. 3.—Per cent weight change vs. time of exposure to fungi for treated and untreated specimens of yellow pine, Douglas-fir, tupelo gum, and red oak.

[6]Richards, C. A. and Addoms, R. M. 1947. Laboratory methods for evaluating wood preservatives; preliminary comparison of agar and soil culture; techniques using impregnated wood blocks.

Table 4.—PILOT PLANT TREATMENT OF SOUTHERN PINE POLES*

Copper Formate in Treating Solution %	Pole No.	Vol. cu. ft.	Air Dry wt., lb.	Solution Pickup %	Copper in Sapwood %
	1	1.69	67.0	78.4	
	2	1.77	65.5	84.1	
0.82	3	1.05	46.0	67.4	0.31
	4	1.77	67.0	82.1	
	5	1.69	67.0	76.2	
	6	1.77	64.0	108.8	
	7	2.00	80.5	95.8	
0.83	8	1.30	65.5	80.9	0.34
	9	1.05	42.0	93.0	
	10	1.30	66.0	92.5	
	11	1.55	68.0	79.5	
	12	1.02	44.0	95.5	
0.77	13	1.85	67.0	103.9	0.38
	14	1.31	63.0	92.9	
	15	1.85	66.0	100.8	

*Size—approximately 5.5 in. diameter at top, 6.5 in. diameter at butt, 9 ft. long. Heartwood—1 in. diameter cylinder in middle of poles. Penetration—100% of sapwood in all poles.

Table 5.—PILOT PLANT TREATMENT OF SOUTHERN PINE 2 x 4's*

Copper Formate in Treating Solution %	Piece No.	Vol. cu. ft.	Air Dry wt., lb.	Solution Pickup %	Copper in Sapwood %
	1	0.368	13.0	115.3	
	2	0.368	13.0	119.2	
	3	0.368	13.5	92.7	
0.77	4	0.197	5.5	127.3	0.57
	5	0.368	12.0	125.0	
	6	0.368	13.0	123.0	
	7	0.368	14.5	100.0	
	8	0.368	13.0	119.2	
	9	0.368	13.5	111.0	
1.44	10	0.238	9.0	94.5	0.91
	11	0.368	13.5	96.3	
	12	0.368	15.0	86.7	
	13	0.368	12.0	87.5	
	14	0.368	13.5	85.2	
	15	0.238	9.5	73.8	
	16	0.368	13.0	73.0	0.42
	17	0.368	14.5	69.0	
	18	0.368	14.0	71.5	
1.11	19	0.368	12.0	75.0	
	20	0.238	9.0	83.4	
	21	0.368	12.5	88.1	
	22	0.368	14.0	78.6	0.47
	23	0.368	12.5	84.0	
	24	0.368	13.5	62.9	
	25	0.368	14.0	60.7	

*Size—5.89 sq. in. cross section—9 ft. long. Heartwood—present in several pieces. Penetration—100% of sapwood.

3. Pressure period, 175 psi. 1½ hrs.
4. Withdrawal of preservative solution.
5. Steaming period, 108°–125° C., 3–6 hrs.

Treatment of Wood: Fifteen Southern pine poles (5.5 in. at top, 6.5 in. at butt, 9 ft. long) of uniform sapwood content were treated in groups of five as outlined in Table 4. One representative pole from each group was used for sampling.

Twenty-five Southern pine 2 x 4's were treated in two batches of six and a third batch of thirteen pieces as outlined in Table 5. From each lot of six pieces, one 2 x 4 was selected for testing. Two pieces were selected from the lot of thirteen 2 x 4's.

Three red gum and one American elm cross ties were treated in two charges. Three red oak and one white oak cross ties were treated in two charges. Also, two air dry and two green Southern pine cross ties were treated in two charges as outlined in Table 6.

Results: The results of tests on treated wood are given in Tables 4, 5, and 6.

A. *Poles.* The sapwood was completely penetrated and the combined copper was from 0.31 to 0.38%.

B. *2 x 4's.* Penetration appeared to be complete and the copper concentration of the wood varied from 0.42% to 0.91%.

C. *Cross ties.* Sapwood penetration in the red gum was excellent, but there was no evidence of penetration in the heartwood. In the oak, the sapwood was easily penetrated, but the heartwood, which contained tyloses, was not penetrated. The sapwood of the pine was also easily penetrated.

Physical Tests on Treated Wood

A series of physical tests, including static bending, compression parallel to grain, and hardness, were carried out on specimens of Southern yellow pine, graded as No. 1 kiln dried lumber of minimum quality, and top quality Indiana red oak. Sixteen foot lengths of each specimen were cut in half, and one piece of each length was treated by the NCG process to give a copper content of 0.45%. The corresponding untreated pieces were used as matched specimens for control.

Standard methods for testing small clear specimens of lumber, ASTM Designation D–143–49, were employed. The strength tests were carried out in a 120,000 pound Baldwin–Southwark Universal testing machine, and the results were subjected to statistical analysis.

In no case was there a statistically significant difference between the treated and untreated wood in any of the physical tests.

NCG chemical preservative treated samples of white and red oak having a thickness of ¾" have been laminated and tested by Gamble Bros., Louisville, Ky. The wood being free of oil presented no problems in lamination. Furthermore, weathering and shear block tests on the laminated samples showed both wood and glue bond stronger in NCG treated wood than in natural (untreated) wood. All tests were conducted according to ASTM specifications.

Mahogany veneer treated by NCG chemical preservative process has been laminated into marine plywood by Nickey Bros., Memphis, Tenn. Likewise there were no problems in the lamination of the veneers into plywood. Double boiling standard tests for glue line quality shows that the effect of the preservative treatment is not harmful to the glue line.

For measuring the electrical characteristics of treated and untreated wood specimens, tests were performed in accordance with ASTM No. D 257–49T. In 80% of the specimens tested, the treated woods have a higher resistivity than the untreated wood. For the other 20%, the results were statistically about the same. Thus, it is apparent that the small amount of copper introduced by this process is in a form which does not affect the electrical properties of the wood.

The preservative is odorless, and the treated product is non-toxic and non-irritating to humans. Since no oil is present, the wood can be processed as natural (untreated) wood, which makes it ideal for many end uses in that it is entirely clean and can be painted, laminated, or glued. The treated wood has a slightly darker color as a result of the treatment.

Table 6.—PILOT PLANT TREATMENT OF CROSS TIES* OF VARIOUS SPECIES

Copper Formate in Treating Solution %	Tie No.	Species	Sapwood %	Vol. cu. ft.	Air Dry wt., lb.	Solution Pickup %	Copper in Sapwood %
1.44	1	Red gum	80	3.4	137.0	73.8	----
	2	Red gum	85	3.5	136.5	99.3	0.75
1.32	3	Red gum	68	3.4	145.0	23.8	0.31
	4	Amer. elm	0	3.7	146.5	35.5	----
1.11	5	Red oak	10	3.2	163.5	28.8	0.45
	6	Red oak	4	3.2	172.0	24.4	0.33
0.39	7	White oak	8	3.4	204.0	10.1	0.42
	8	Red oak	0	3.4	173.5	30.2	----
0.80	9	Southern pine	0	3.7	130.5	21.8	----
Air dried	10	Southern pine	0	4.0	122.0	41.0	----
0.82	11	Southern pine	85	3.8	191.0	44.0	----
Green ties	12	Southern pine	90	3.7	159.0	62.0	0.35

*Size 7" x 9" x 8'6".

Preparation of Paper from Treated Wood Chips

In another paper[7] it has been shown that the copper that remains in cellulose after the NCG preservative process appears to be bound to adjacent cellulose molecules in the amorphous regions of fibers that are practically pure cellulose, such as cotton, viscose rayon, and linen. In this paper is given the evidence of the formation of a copper-cellulose complex, established through X-ray diffraction, radioactive tracer techniques, and other methods. The following experiment was designed to gain information regarding the bonding of copper in lignocellulose. NCG treated chips, and similar untreated chips, were used to make paper by the Kraft (sulfate) process and by the neutral sulfite (semi-chemical) process. Also, paper made from untreated pulp by these two methods was treated by the NCG preservative process.

It was possible to account for 98.0% of the copper in the Kraft process, and for 99.4% of the total copper present in the original NCG treated wood chips in the sulfite process. In both cases, it appears that the cellulose of the wood has absorbed its proportion of copper.

The resulting paper and untreated paper were tested for resistance to mildew, specifically *Chaetomium globosum.* The untreated Kraft paper had a heavy growth of *C. globosum* and the untreated sulfite paper had a moderate growth of the organisms. Both controls were badly deteriorated. On the other hand, both types of paper made from wood chips treated by the NCG preservative process were entirely free of mildew. Both types of paper from untreated wood showed no growth of mildew after the NCG preservative process had been applied.

It may be concluded that mildew-resistant paper can be made from NCG preservative treated wood chips by both the Kraft and sulfite proc-

[7] A copper process for prolonged microbiological protection of cellulosic fabrics by chemical modification. By E. Abrams and I. R. Bottoms. To be published in Textile Research Journal, Aug. 1956.

esses. The copper is bound tightly to the cellulose and subsequent chemical reactions involved in the digesting of wood do not remove the copper or diminish the mildew resistance of the final product.

Summary

The process described shows that a firmly bound copper preservative can be fixed in wood when a dilute aqueous solution of copper formate is applied to the wood which is thereafter subjected to heat to bind the copper chemically in the wood. Tests show that the wood thus treated is extremely resistant to terrestrial agents of decay and has excellent resistance to attack by marine borers. The threshold value of copper to provide this protection has been established as around 0.15% to 0.20%.

The effective permanence of the treatment indicates that even under extreme conditions of exposure a long term preservation is accomplished, and a life well in excess of 20 years of protection can be expected.

Acknowledgments

It is a pleasure to acknowledge the assistance of Miss Jeanette Esslinger, Mrs. Betty Wyatt Giesemann, Dr. Reavis C. Sproull and other members of the staffs of the Southern Research Institute and the Marine Laboratory, University of Miami, who have been connected with this development, as well as that of Mr. E. L. Russell of the Crestwood Research Laboratories of National Cylinder Gas Company.

Discussion

P. B. Mayfield (Barrett Division, Allied Chemical and Dye Corp.): You mentioned the use of an autoclave for heating the wood after impregnation. How is this done in a commercial treating plant?

Mr. Miller: After the wood has been impregnated and the solution withdrawn, live steam is admitted to the cylinder and brought to 15–20 pounds per square inch, which represents a temperature of about 250–260° F.

George Fahlstrom (Osmos Wood Preserving Co.): Were the blocks subjected to decay tests and shown in Figure 2 and Table 1 subjected to leaching or weathering before decay?

Dr. Abrams: No, they were not.

Mr. Fahlstrom: What was the water-holding capacity of soil used in the decay tests? 20 per cent moisture content gives too low rate of decay to be comparable with standard procedures commonly used in soil-block tests.

Dr. Abrams: The moisture content of our soil is 30 per cent. It results in 100 per cent reduction in strength of untreated heavy duck fabric in from seven to ten days. Similar fabric treated with copper naphthenate (0.8 per cent Cu) begins to lose significant strength after nine weeks of soil burial.

Mr. Fahlstrom: Is retention reported of the percentage of copper metal based on oven-dry weight of wood? The same percentage of copper on pine will be less in lbs./cu. ft. than for red oak, for example, because of specific gravity. Could the copper metal retention be given in lbs. per cu. ft. of wood for uniform reporting?

Dr. Abrams: Retention is based on oven-dry weight. By using the specific gravity of the particular specie of wood, it is possible to convert the per cent copper retention to lbs. per cu. ft.

Mr. Fahlstrom: Was the Douglas-fir used in the test procedure heartwood or sapwood?

Dr. Abrams: It was sapwood.

Mr. Fahlstrom: Has any soil block test work been done using the fungi *Poria monticola* (Madison 698) since this fungi is known to be tolerant of copper compounds? If so, what were the results?

Dr. Abrams: No soil block test work has been done with *Poria monticola.*

An Iranian Charcoal Kiln[1]

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A carbonizing apparatus used in Iran operates on quite different principles from other kilns described in American and western European literature. It is suggested that thorough study of this kiln might enable design of a structure to produce uniformly high yields of good quality charcoal without heavy capital investment.

DURING THE SPRING of 1955 the writer spent three months in northern Iran at the request of the Foreign Operations Administration to advise Iranian personnel in improved methods of recovering charcoal from wood. Charcoal is important in Iran and an estimated 1 million tons are consumed annually. In some areas it is the only domestic fuel. Methods of production are generally rather crude and the average charcoal yield per unit volume of wood is lower than that consistent with good forest conservation in a land of limited forest resources. Quality of charcoal produced varies greatly and often is rather poor.

One specific objective of the trip was to show Iranian personnel how to build and operate Connecticut-type[1] kilns with materials locally available. Three Connecticut-type kilns, varying in capacity from 2½ to 6 cords, were built and operated to produce good yields from Iranian woods.

Another aspect of the work was to study possible improvement in the charcoal-making apparatus now used in northern Iran. A structure, said to be typical of those used in this region for carbonizing wood, was built and operated for a period of a month for the writer's observation. The structure will be referred to as a "kiln" although the term is not entirely appropriate. A discussion of it is best preceded by a description of the structure and a typical operations schedule.

Description of Structure

Figures 1 and 2 show that the vertical walls are about 27 inches thick and are formed of timbers, stones, and mud. The timbers are notched at the corners. The mud, which is a mixture of an adobe-like soil and water,

The Author: A. R. Olson graduated from the New York State Ranger School in 1927, has been on the staff of The Connecticut Agricultural Experiment Station since 1928. His principal work has been in charcoal kiln development, wood preservation, and wood strength properties. On an assignment in Iran in 1955 at the request of FOA, he demonstrated construction and operation of Connecticut type kilns as well as several simple methods of wood preservation.

[1] Hicock, H. W., Olson, A. R., and Callward, F. C. 1951. The Connecticut charcoal kiln. Bull. 431, Extension Service, College of Agriculture, University of Connecticut, Storrs, Conn.

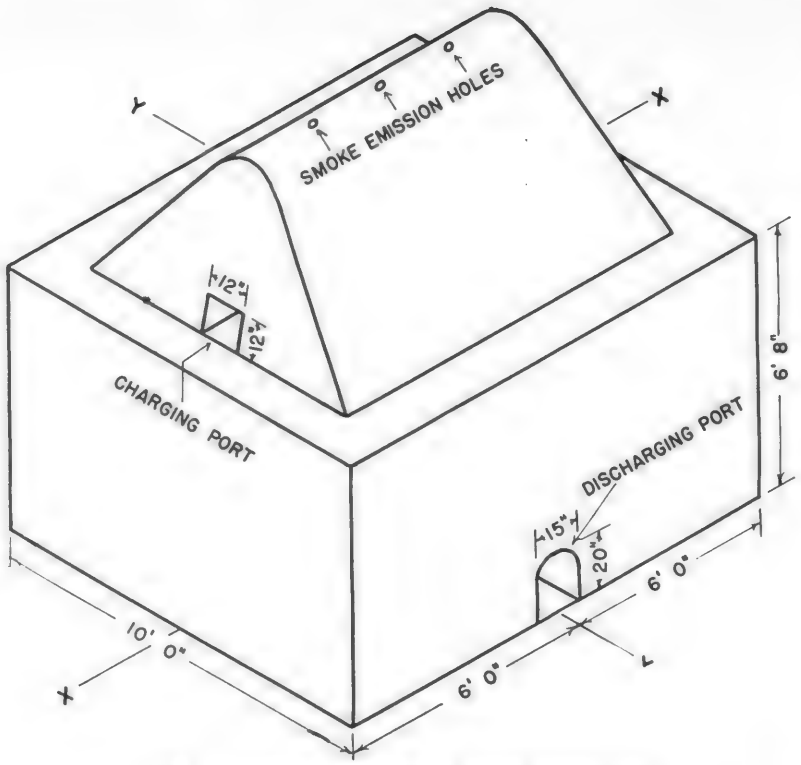

Fig. 1.—Isometric drawing of an Iranian charcoal kiln.

is also used locally in making bricks. The sloping part or roof is from about 8 to 12 inches thick; it is built up entirely of mud on a wooden form which later burns out. It will be noted that there is a charging port in one gable end through which wood is introduced, a discharging port near the ground through which charcoal is withdrawn and three small holes for smoke emission along the ridge; also, the inside edges at the ground line are rounded to facilitate removal of charcoal. Additional features not shown are a ramp and loading platform for charging wood and a roof over the entire structure to shed rain.

After the structure is completed, a slow fire is maintained in it for five days to dry out the walls and get them hot enough to permit carbonization of wood as described below. This requires about 7 cords of wood. At the end of the heating period, the kiln is ready for the first charge of wood to be carbonized.

Operating Schedule

About ¾ cord of unseasoned wood 2 meters (6⅔ ft.) long and up to about 7 inches in diameter is fed in through the charging port on top of the residual ash and charcoal from the wood already burned. All other openings are closed with stones and/or mud during charging and, immediately after charging, the charging port is similarly closed.

Assuming that charging with wood is completed by about 11:30 A.M., nothing further is done until 2:00 P.M. During the preceding 2½ hour period, the wood is partly dried out and vaporization of moisture cools the hot ash and charcoal so that it can be raked out with a long-handled hoe onto the ground, where it is spread about 6 inches deep. It is raked over periodically for about two hours, using water if necessary to quench any glowing charcoal. The first charge removed contains overburned charcoal and much ash. Most of it is discarded. Subsequent burns produce charcoal with very little ash. When the charcoal is sufficiently cooled, it is put in bags for shipment. Removal of the charge takes about one hour and as it is removed the wood settles appreciably.

Charcoal removal will be completed by about 3:00 P.M. At this time, with the discharge port partially open, the three holes in the roof are also opened and kept open for about a half-hour. The apparent purpose is to raise the temperature of walls and charge to compensate for heat lost in driving off and evaporating water from the unseasoned wood introduced 3½ hours before. After a half hour, the charcoal removal port is closed with stones and mud and remains closed for the remainder of the cycle.

At 3:30 P.M. the three smoke emission holes are closed and about ¾ cord of unseasoned wood is introduced through the charging port to fill the kiln. The charging port is then closed and the three smoke emission holes re-opened. These steps take about a half-hour.

After 4:00 P.M. the first day, there is no further manipulation of the kiln for the following 19 hours except to close or re-open one or more of the three holes in the roof. For the first 12 hours, the smoke issuing from these holes will be white, indicating a high content of water vapor. It then increases markedly in density and volume and becomes grayish-white from volatile elements other than water vapor. This continues for some seven hours when the smoke thins out and becomes bluish in color. Some attempt is made to control the duration of the smoke stages, and hence the rate of carbonization, by opening and closing the holes in the roof. This is based on the operator's judgment.

During this 19-hour period, most of the wood has been carbonized and the charge has settled appreciably. The kiln is now in a position to start the second cycle at 11:00 A.M. on the second day by again charging with unseasoned wood; the third cycle at 11:00 A.M. on the third day by charging with unseasoned wood; and another cycle each day.

Handling of wood and charcoal are manual and these operations are tedious and disagreeable.

Comparison of Carbonizing Systems

The Iranian kiln proved to be something of a revelation in that the principles on which it operates appear to be quite different from other apparatus described in American and western European literature. All carbonizing apparatus in use prior to about 1920 is classified by Klar[2] as follows:

(a) Those in which carbonization progresses through the wood mass gradually in response to admitted air; examples—American brick kilns and German "meilers". (The Connecticut kiln operates on this principle.)

(b) Those in which carbonization is accomplished by burning of fuel outside the structure and passing the hot flue gases (depleted of oxygen) through the wood mass; examples—Schwartz, Ottelinska, and Ljungberg kilns.

(c) Those in which carbonization is accomplished by placing the wood mass in a closed structure and raising its temperature indirectly by application of heat to the outside of the structure or internally through ducts

[2] Klar, M. Technologie der Holzverkohlung. 1910 (reprinted in 1920). The information cited was taken from the English translation of Klar's work by Alexander Rule entitled The Technology of Wood Distillation by Klar and Rule, Chapman and Hall, Ltd., London, 1925.

or by both methods of application simultaneously; examples —Swedish Carbo-oven, Bosnian meiler oven, and vertical and horizontal retorts.

Apparatus of these three types are many and may vary greatly in size, shape and construction. They may consist merely of a heap of wood covered with sod and soil or, at the other extreme, may be well engineered and expensive with the operation well controlled. Some are highly mechanized.

In 1921, U. S. patent 1,380,262 was granted to O. F. Stafford for a carbonizing process quite different from those described above. The Stafford process is mentioned briefly by Klar[3] and treated somewhat more in detail by Nelson[4] in his description of the apparatus in actual use at Iron Mountain, Mich. The latter is a well engineered and expensive piece of equipment. In essential details, it consists of a vertical, closed, metal cylinder 40 feet high and 10 feet in diameter with a heat-insulating wall 18 inches thick. Finely divided wood, preheated and virtually moisture free, is fed in at the top by conveyor with admission of little or no air, and charcoal is discharged at the bottom, also without admitting air.

When put into operation, the retort is controlled so that a zone of wood at carbonizing temperature is developed at about the vertical midpoint of the cylinder. Subsequently feed and discharge rates are adjusted to maintain the zone at about the same position. Above the zone is wood varying in states of carbonization from wholly uncarbonized at the point of entrance to fully carbonized in the zone itself. Below the zone is charcoal. Action within the zone is exothermic and enough heat is given off to bring the wood immediately above the zone to near-carbonizing temperature before it actually enters the zone. Maintenance of a suitable balance between feed and discharge makes the process self-sustaining and continuous. All transfer of wood and charcoal is fully mechanized.

Different Carbonization Method

From observations made without instrumentation on the demonstration kiln, it seems evident that carbonization in the Iranian kiln is accomplished in a still different manner. Apparently, heat developed during carbonization is conducted into and stored in the thick walls and then released later to bring a subsequent charge of wood to carbonization temperature. There was little heat loss through the walls and even after continuous operation for a month, their outer surfaces were barely above air temperature.

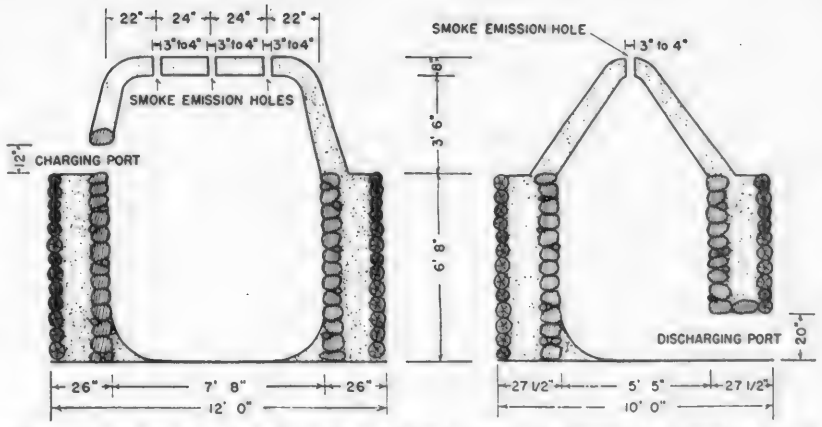

Fig. 2.—Vertical section X to X (left) and Y to Y (right) of charcoal kiln shown in Fig. 1.

It will be noted in the typical operations schedule that, following the charging of wood to fill the kiln at 3:30 P.M., the smoke issuing from the kiln for the next 12 hours is white and of a nature indicating a high content of water vapor. Then, rather abruptly, the smoke increases markedly in density and volume and becomes grayish white from elements other than water vapor. This indicates that, during this 12-hour period, the wood is being heated and dried by heat stored previously in the walls and that only limited carbonization is taking place.

At the end of this period, carbonization evidently starts rather suddenly as evidenced by the change in color and nature of the smoke. The wood charged in just prior to 11:30 A.M. for purposes of cooling the charcoal is also heated and dried to some extent during the 2½ hours prior to charcoal removal.

The Iranian kiln is unlike any of the three types classified by Klar in that, except for a half hour period (3:00 to 3:30 P.M.), no air is admitted other than that introduced while charging wood or discharging charcoal; no heated gases are passed through the wood mass other than those formed during the carbonization process nor is heat applied from an outside source. Furthermore, a complete cycle in the Iranian kiln is completed in 24 hours which permits a high daily rate of production.

In apparatus of the other three types, a complete carbonization schedule usually involves two steps—the first being carbonization, the second cooling in the same or a different structure. The two steps may require from a few days to a month depending on the type of apparatus, its size, and the amount of auxiliary equipment available. In a few cases operation is continuous (Seaman Process) or nearly so (Gröndal Process), rather than stepwise.

Comparison with Stafford Apparatus

The Iranian kiln is also unlike the Stafford apparatus in that construction is crude and only unseasoned stick or billet wood is carbonized in it. The two apparatus are, however, similar in several other respects. The walls of both are well insulated and both are operated continuously, the Iranian on a 24-hour cycle and the Stafford on a very short cycle of feeding and discharge.

Apparently both apparatus depend upon heat developed during carbonization but differ in the manner in which it is utilized. In the Iranian kiln, heat is apparently conducted into and stored in the thick walls during carbonization to be used in bringing wood introduced later up to the temperature necessary for conversion to charcoal. The Stafford apparatus depends on heat developed exothermically during carbonization of a portion of the wood charge to bring more wood up to carbonizing temperature. The function of the heavy insulation cover of the latter is apparently to prevent loss of heat rather than to act as a heat reservoir.

Reasonably Good Yield

In the demonstration kiln, maximum yields of more than 800 pounds of good quality charcoal per cord of unseasoned wood were produced. This is as much as can be reasonably expected from unseasoned woods of a density simliar to American oaks, maples, hornbeams, etc., when carbonized in apparatus in which the process is not subject to a high degree of control. Estimates by Iranian personnel indicated, however, that the average yield of this type of kiln is less than 600 pounds, much of it of low quality. Reduced yields and poor quality are apparently due in part to poor kiln construction, in part to inefficient operation, and in part to rough handling of the charcoal on removal from the kiln.

[3] See footnote 2.
[4] Nelson, W. G. 1930. Waste wood distillation by the Badger-Stafford process. Ind. Eng. Chem. Vol. 22, 312–15.

Although no recorded information was obtainable on the length of time the Iranian kiln had been used in northern Iran, discussion with individuals left the impression that it had been known for a very long time. Details regarding construction and operation of the kiln are usually transmitted verbally among charcoal makers. The art is consequently quite well known but the history of the art is lost.

Experience with the demonstration unit suggests that a thorough study of the Iranian kiln would make it possible to design a structure that could be operated with much greater ease to produce uniformly high yields of good quality. Such a kiln might find wide use where heavy capital investment is not justified.

Sawing Rates, Sawdust Chambering, and Spillage

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The flow of sawdust in gullets is described and new experimental evidence presented on the role of the clearance volume between the saw plate and the kerf in accommodating sawdust particles. Experimental devices to pick up spillage sawdust are illustrated and their effectiveness evaluated.

IN ACTUAL PRACTICE, the rate of cutting with headsaws, edgers, resaws, and straight-line and other rip saws is quite variable in terms of lineal feet per minute. This rate may range from about 20 feet per minute with hand feed to somewhere around the 900 feet per minute claimed for some western pine mills.

The linear rate of feed, however, is not a good index of sawing rates, since it ignores the depth of cut, or width of cutting face. Production depends on the area sawed, so that a lineal feed of 40 feet per minute of redwood with a cutting face 45 inches wide would be the equivalent of a 900-foot-per-minute feed of western pine with a 2-inch cutting face. The area sawed would be the same in both cases, 150 square feet per minute.

The apparently great disparity between feed rates in the industry becomes much smaller when the area basis, instead of the lineal basis, is used to express the sawing rate. The area basis excludes kerf width, which becomes important only in relation to power and waste, and thus provides a consistent standard for evaluating saw performance.

It is safe to assume that saws are operated at or near the maximum rate, at least at efficient mills. This maximum could be limited by inadequate power, of course, but the ability of the saw to "stand up to the cut" is the principal limiting factor in saw performance. Assuming that the saw is adequately powered and is also properly tensioned and sharpened, the major factors that affect its ability to saw satisfactorily are the density and other characteristics of the wood being cut, the feed per tooth, and the gullet area.

The density and other wood characteristics must be accepted as they come, whereas feed per tooth is optional with the sawyer. Gullet area, though constant for a given saw, could be changed somewhat by regrinding or by use of blades with other tooth spacings or tooth forms. Of these mutually related factors, only feed can be controlled instantaneously.

Feed per tooth and wood strength or cutting resistance naturally determine the forces on the saw teeth and blade. These forces have a definite limit beyond which there is an adverse effect on saw behavior that cannot be tolerated. Feed per tooth and width of cutting face determine the amount of material that must be carried out of the cut, in the form of sawdust, by each tooth. Feed per tooth, hook angle, and the strength and physical properties of the wood determine the size and shape of the wood particles (sawdust) and the quantity of particles that can be accumulated and packed in the tooth gullet. The friction caused by this sawdust increases with the tightness of packing, and the power demand rises rapidly as the degree of packing in a full gullet increases. Beyond a certain limit, additional crowding of sawdust into the gullet causes saw misbehavior, so that the amount of solid wood each tooth can remove in the form of sawdust is limited.

Since the wood removed per tooth is an important factor in saw performance, the ratio of wood removed per tooth to gullet volume is a useful index of operating conditions. This ratio may be called the Gullet Feed Index, or GFI, and

$$GFI = \frac{f \times w \times k}{a \times k} = \frac{f \times w}{a}$$

where f is the feed per tooth, w is the width of cutting face, k is the width of the kerf, and a is the area of the gullet. Since $f = \frac{F \times p}{v}$, where F is carriage speed, p is pitch of the teeth, and v is saw velocity, all expressed in inches, then

$$GFI = \frac{F \times p \times w}{v \times a}$$

As gullet area and pitch are constant for any given saw, its GFI will increase directly with feed and width of cutting face.

Since the GFI is based on exact factors, it serves as a reference point or basis for analysis of the chambering and packing of sawdust in the gullet.

The relationship between packed sawdust volume and original solid wood volume should be known if gullet area is to be fitted to the feed rates to be used and the widths of cutting faces to be sawed. The packed volume of sawdust, in relation to original solid volume, is not easily determined. A few scattered observations of plugged gullets have been made where feed rate and face width were known and could be used to compute the original solid wood volume removed per tooth. Such observations indicated that, on the assumption that all the wood removed by a tooth is retained in the gullet, which is doubt-

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

The Author: L. H. Reineke joined U. S. Forest Service in 1923 as junior forester, received B.S. in forestry from Cornell U. in 1929. After year of graduate study at U. of California, he joined Northeastern Forest Experiment Station. Reineke came to the Laboratory in 1942, has since worked on woodworking machinery and methods research. In 1950 he developed first duo-kerf saw, a rip saw which cuts and planes wood at same time.

ful. the packed sawdust occupied 2 to 3 times the volume of the solid wood that was removed. In one instance, a 1 : 1 ratio was reported.

The degree of packing that results in plugging of gullets can be indicated by the "springback" in the sawdust. Springback measurements are infrequent and such measurements indicate that the thickness of the sawdust plugged in a gullet may increase to as much as 1.45 times the kerf width after release from the confinement of the kerf walls.

Compression-Springback Relationship

To obtain a rough idea of the pressure such springback indicates, some fresh sawdust cut by a circular saw from a freshly cut yellow birch log was given a compression-springback test in a standard testing machine.

The testing jig consisted of a ram and a 2-inch long cylinder of brass, with an internal diameter of 1.5 inches, which rested on a metal plate. With the jig in the testing machine, a measured and weighed volume of the sawdust (1.005 cubic inches) was poured into the cylinder and gently leveled. The loose-fitting piston or ram was gently lowered to the sawdust surface and rotated two turns for final leveling, and an initial measurement was made of overall height from the top of the ram to the base of the bore.

Compressive loading was applied at the rate of 0.5 inch per minute, and height measurements were made at selected increments of load. After a designated small load was reached, the pressure was reduced to zero, except for the jig pressure of 1.42 pounds per square inch, and a height measurement was made. Loading was re-applied to a somewhat higher final load, and height measurements were made at pressure increments and final load, and after release. This procedure was repeated with a higher final load for each cycle. Any water squeezed out during loading was immediately blotted up to prevent re-absorption.

After the last cycle, the sample was weighed to determine squeeze-out or water loss, and then dried in an oven to determine the residual water, dry weight, and original solid wood volume (on the basis of specific gravity from solid wood samples of the log).

Since the compacting of sawdust in a gullet occurs in a single cycle, the repeated cycles needed to determine the broad ranges of pressures and springback might distort the compression-springback picture. Additional samples were therefore run in single cycles, and a new charge of sawdust was used for each run.

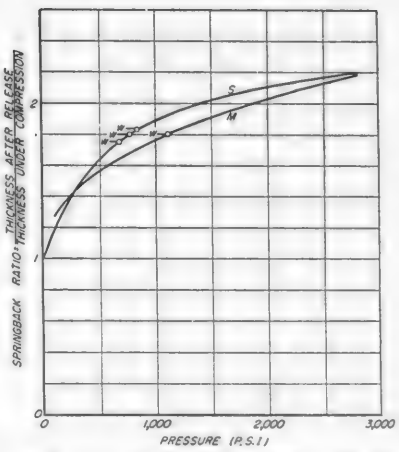

Fig. 1.—The relation between pressure and springback for yellow birch sawdust is indicated by curve S for single loadings and curve M for multiple loadings. The points of water squeeze-out are indicated by W.

As anticipated, the relation between pressure and springback with multiple loadings differed somewhat from springback with single loading, as shown by the curves of Fig. 1, but the difference between the curves is not too great. Curve M, for multiple loadings, is somewhat straighter and lower than curve S, for single loading. With multiple loadings, the removal of pressure between cycles may permit some shifting of particles to more fully occupy the voids, thereby increasing the total contact area between particles. The pressure applied to the mass of sawdust thus is distributed over a greater contact area, and the effective pressure per unit of contact area is thereby reduced, with a resultant decrease in springback.

With single loadings, pressure per unit of contact area is higher and springback is therefore greater, because the voids in the mass leave less contact area until the pressure rises enough to cause deformation or flow of particles into the voids. This causes the falling off of the curve S at the higher pressures.

The two curves reach the same value in the neighborhood of 2,800 to 3,000 psi, at which pressure it is likely that elimination of residual voids by deformation has occurred. The reduction of voids between particles reduces the space available for retaining the water forced from the cell cavities, so that free water is squeezed from the compressed mass. The points indicated by W in Fig. 1 show the pressures at which squeeze-out of water began with sawdust that had 82 per cent[2] of water (dry weight basis).

With multiple loading, a higher pressure was required than with single loading, but the springback at this squeezeout point is essentially the same with either single or multiple loading, which indicates that the degree of compaction, rather than the pressure, controls squeeze-out.

In cutting the material from which the test sawdust was obtained, water was pressed out ahead of the saw. Tooth face pressures of 700 psi or more are thus indicated. The pressure of the sawdust against the kerf walls can also be judged from the springback, since curve S indicates that a springback ratio of 1.45 is obtained with a sidewise pressure of 300 psi.

The system of loading used in these tests differs from the compaction process in gullets, where the packing forces are in the plane of the gullet, instead of perpendicular, as they are in these tests. Since the flow properties of sawdust are poor, any pressure developed perpendicular to the plate probably reflects a considerably higher compacting pressure in the plane of the saw plate.

It is apparent, then, that the pressure of the sawdust against the kerf walls can reach a rather high value when the gullets become packed. This is reflected, of course, in the power required to overcome the resulting high friction between the rough kerf walls and the tightly packed sawdust in the gullet during the latter portion of its travel through the cut.

Excessive packing can only result in saw disturbance and an increased cutting resistance that may induce snaking. Compaction of the sawdust in the gullet to a lesser degree should result in cooler and more accurate operation of the saw, but the optimum packing for highest accurate production cannot be determined from present information. Any reduction in compaction, however, will raise the ratio of sawdust to solid wood volume and thus require a larger gullet area (reduced GFI) for removing the sawdust from a given volume of solid wood.

Sawdust Chambering

A thorough understanding of how sawdust accumulates and is packed into a gullet would be helpful in saw design. Only recently have photographs been taken of sawdust action at normal saw speeds[3, 4] but the feed rates were slow and cutting heights were such that the sawdust did not crowd the gullet space. For the high feed rates and wide cutting faces at

[2] This moisture percentage was reduced to 73 and 60 per cent in single-cycle loadings to 1,100 and 2,800 psi, respectively, and to 60 per cent at 2,800 psi with multiple loading.

[3] Chardin, A. 1954. Peut-on scier tous les bois avec la meme denture? Revue Bois et Forets des Tropiques, No. 33, p. 41.

[4] Englesson, T., Hvamb, G., and Thunell, B. 1954. Noen resultater fra undersokelser over saging med och mot fibrene. Norsk Treteknisk Institutt, Blindern, Oslo. Bul. No. 7.

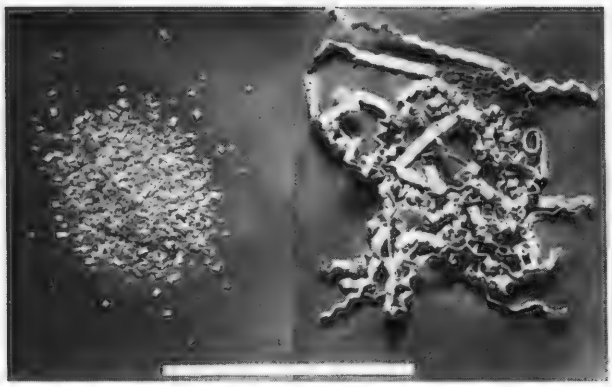

Fig. 2.—Fragmented particles (left) and ribbon-like chips.

Fig. 3.—Different chip formations caused by various cutting conditions.

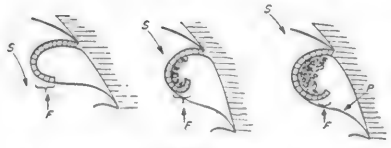

Fig. 4.—Movement pattern of chip stream in gullet.

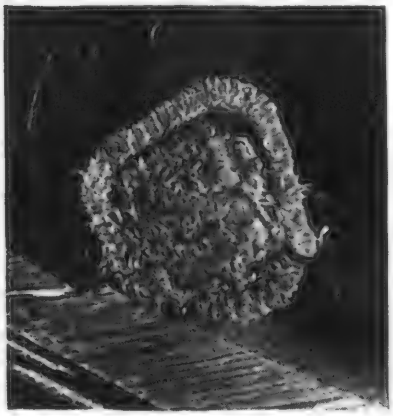

Fig. 5.—In this enlarged view, the filled gullet is supporting the chip stream from the point of inflection to the cutting path.

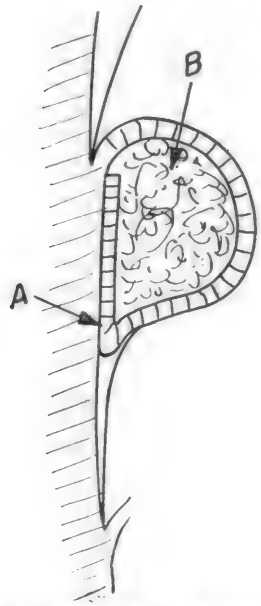

Fig. 6.—If additional chips are forced into this gullet, the chip stream will buckle and become jumbled at point B.

headsaws, the pattern of sawdust behavior is different in some respects.

The classical picture of sawdust forming a ribbon that slides around the gullet, across the gullet opening, and back around the gullet in an internal spiral coil is hardly realistic. Observations by the author and others[3, 4] indicate that fragmentation of the chip occurs in the immediate vicinity of the cuting edge, and the particles are directed forward from the tooth face, sometimes with sufficient energy to strike and rebound from the opposite side of the gullet. This is particularly true with spring-set teeth, since the chip width is much less than the kerf width and the particles are relatively free to move. With swaged teeth, thin chips may turn sideways and move freely in the kerf, but thick chip particles have no room to turn and the contact between kerf walls and the sides of the chip help restrain movement. Such fragmented particles (Fig. 2, left) obviously cannot form a continuous coil in the gullet.

When a circular saw cuts a wide face, the movement of the tooth at the top of the face is nearly parallel to the grain. The first part of the chip is then flexible, and may have bending failures without complete breaks that separate the chip into fragments. With a swaged tooth, such ribbon-like chips (Fig. 2, right) may begin to coil up, but often they tend to buckle like an accordion pleat from resistance to forward movement that results from either side friction or butting against the front of the gullet at an angle that does not favor forward flow. With inserted-tooth saws, a holder that projects forward of the inserted bit forms a slight obstruction to chip flow and may cause such buckling, illustrated at A, Fig. 3.

Where the feed is fairly heavy and the cutting face does not extend to the top of a circular saw, the chip may fracture without complete separation of the particles. Such conditions would produce a ribbon (B and C, Fig. 3) that would follow the curve of the gullet to some extent. However, when the end of the ribbon started to climb up the front of the gullet, it would have no supporting surface behind it to counteract the frictional drag between the kerf walls and the sides of the chip. Thus, the free end of the chip ribbon would be slowed down by friction with the kerf walls and the saw would then catch up with it, as shown in Fig. 4.

The frictional forces break off sections from the chip ribbon, which accumulate in a position where they can increase the opposition of the chip to the frictional forces near the bottom line of the gullet. As a result, the point at which frictional forces promote chip breakup moves toward the cutting circle, and eventually the chip may continue as a ribbon toward the top of the gullet, as in Fig. 5.

Ordinarily, however, sections of the ribbon will break off at the point of inflection, P, in figure 4 C, along the front of the gullet. At the point of inflection, the curvature of the gullet on which the ribbon slides becomes convex and no longer supports or guides the chip, which may then break off in long sections and be overtaken by the lower part of the tooth face or upper part of the holder, as at D in Fig. 3. If the coherence between the chip fragments is low, the forward end of the chip stream may continue to separate into free particles that eventually fill the gullet space and provide support to the chip stream beyond the point of inflection. Fig. 5 shows such a filled gullet supporting the chip stream from the point of inflection to cutting path.

Further cutting may force the chip stream into the unoccupied corner as at A, Fig. 6. Thereafter, additional chips can be forced into the gullet only by buckling the chip stream at B, which produces a jumble of particles in the vicinity of B.

This sequence for swaged-tooth saws making heavy cuts is, perhaps, more regular and recurrent than can

be expected for saws with spring-set teeth. Since a spring-set tooth makes a corner cut along only one side of the chip, the tipping or twisting motion thereby applied to the chip promotes its separation into independent particles that are turned in a direction favorable to free movement. Since chip thickness with a spring-set saw is limited by top bevel, a feed rate that could form a continuous chip stream is not feasible. As a result, a forward spray of particles and random pile-up against the rear of the gullet is the most likely pattern.

Gullet Capacity

The gullet capacities previously mentioned, even the most optimistic (based on a 1:2 solid volume-sawdust ratio), do not begin to match apparent gullet capacities encountered in the industry. Based on feed rates claimed by some operators of western pine sawmills, the computed volume of solid wood removed exceeds the gullet volume, which gives a GFI greater than 1.0.

This irregularity may be the product of one or more factors. First, low-density woods such as pine may undergo some densification due to squeeze-out of water and mechanical compacting in the gullet. Second, an appreciable number of wood particles are only partially detached from the kerf walls and, therefore, never take up gullet space. Third, there is a wide range in sawdust particle size, even for one particular feed rate, so that a portion of the particles are sufficiently fine to escape from the gullet into the clearance spaces between the blade and kerf walls. Other particles may lodge in the irregularities of the sawed surfaces.

Densification by water loss and compaction has not previously been recognized as a factor in gullet capacity, yet it has some effect on capacity. Adherent fibers may have a more important part in the sawing of fibrous or woolly species, such as spruce and cottonwood. Spillage has been advanced by the operators of pine sawmills as the main factor in achieving sawing rates that exceed the rates indicated by gullet space, but spillage has also been labeled by many as a cause of heating of the saw.

Densification of Sawdust

Green sawdust, before it was cut, obviously consisted of wood cells with the void spaces more or less filled with water or sap, and with the cell saturated with water. In the cutting operation, many cells are cut or torn open and others are burst open by the cutting pressure, with the result that water is forced from the cells. After

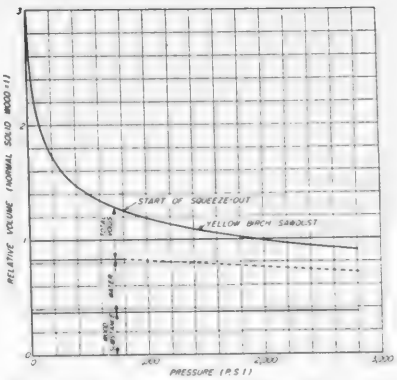

Fig. 7.—Pressure-volume relationships for yellow birch sawdust.

the pressure is removed, this water may remain on the surfaces of the sawdust particles or in the voids between the particles.

As the sawdust accumulates in the gullet, the pressure increases and forces the particles together more closely. Under increasing pressure, the local contact areas between particles increase, and the surface water is forced into the voids. With increasing pressure, the particles are pressed together more closely, and the volume of voids is reduced. The increasing amount of water forced into the decreasing volume of voids reaches a point beyond which any further decrease in volume of voids will result in squeezing water out of the sawdust mass.

Such void saturation points are indicated by the W's in Fig. 1 for the springback test sawdust. Further increases in pressure reduced the moisture content from the original 82 per cent to 73 per cent (dry weight basis) under 1,100 pounds pressure and to 60 per cent under 2,800 psi. These moisture reductions represent volume reductions from 100 per cent to 89.3 and 72.6 per cent, respectively, if the volume at the start of squeeze-out is taken as 100 per cent.

At some point in the compacting process, the voids between particles may be eliminated by the deformation and shifting of the particles under pressure. Thereafter, further volume reduction can be achieved only by collapsing the cell cavities, expelling any contained water, or by squeezing water out of the cell walls. It is doubtful that squeeze-out from the cell walls is ever accomplished in sawing, since the voids still existing in the sawdust mass at a pressure of 2,831 psi amount to 19 to 32 per cent of the compressed volume.

In compaction by removal of water and elimination of voids within and between particles, the aggregate volume of all voids decreases rapidly with an increase in pressure in the low pressure range. The rate of decrease is rather slow, however, after the squeeze-out point is reached, as shown in Fig. 7, in which total volume and volumes of the wood substance, water, and voids in yellow birch sawdust under pressure are related to original solid-wood volume of the sawdust.

At the water squeeze-out point, the compressed sawdust volume ran from 117.5 to 129.8 per cent of the solid green wood volume. Compressed sawdust volume equaled solid green wood volume at pressures of 1,613 to 2,177 psi.

The pressure-volume relationships given above are for yellow birch. For other species, especially low-density species such as pine, less pressure will be required. Measurements of pressure in the gullet, with various degrees of packing and with a range of wood densities, will be necessary to establish more fully the extent to which sawdust is densified within the gullet.

Spillage of Sawdust

The occurrence of spillage has been inferred from evidence such as loose sawdust on board surfaces, polished areas on saws, cutting rates in relation to gullet area, and other observational evidence, but until now, direct evidence and measurements have not been obtained.

Measurements of spillage, lodged sawdust, and adherent fibers, in relation to feed rate, width of cutting face, gullet size, and swage or side clearance, were desired as part of a comprehensive study by the U. S. Forest Products Laboratory of bandsaw tooth and gullet forms and their effect on saw performance. The procedure developed demonstrates conclusively the occurrence of sawdust spillage, and early results indicate definite relationships between spillage, feed, width of cutting face, and side clearance.

To obtain this information,[5] a rather simple but effective adaptation of an industrial tank-type vacuum cleaner was used. A pickup was designed that would collect spillage sawdust only. This spillage was collected in a paper vacuum-cleaner bag, of the domestic cleaner type, mounted within the tank of the industrial unit.

The pickup was made of galvanized sheet iron in the form of a long tube, rectangular in cross section throughout most of its length, that faired off into a downward-tilted tapered section of circular cross section to fit into the end of the vacuum hose (Fig. 8).

The rectangular portion was closed at the end except for a central ¼-inch slot that continued vertically through the top and bottom of the rectangular

[5] Equipment and personnel were made available for this work by the Division of Conservation, Department of Forest Products, Michigan State University, East Lansing, Mich.

section of the tube. Two angle brackets along each side of the rectangular portion served the triple purpose of mounting the unit on top of the lower saw guide, adjusting the slot width to counteract spreading or pinching, and holding in position two 0.010-inch-thick spring brass wipers bent upwards through the bottom slot and pressing against the sides of the saw blade. These wipers may be readily replaced when worn or damaged.

The pickup is shown installed (Fig. 8) on a 6-foot band mill. The dowel through the front corner is part of an instrument to measure deflection. Construction details are shown in Fig. 9.

Dimensions must be adapted to the mill to be used, to provide clearance for the carriage bolsters and ¼-inch clearance between the top of the pickup and the bottom of the test cants. The slot should extend perhaps ½ to ¾ inch behind the back edge of the saw, and the front of the pickup should be ⅛ to ¼ inch back of the gullet bottoms when the blade is in normal running position. If the saw oscillates when running, or rides back on the wheels when cutting, the ¼-inch distance may be necessary. The downward tilt of the hose end was required to keep the hose clear of the cant bottom. It is advisable to remove the pickup to prevent damage from branch stubs or dropping slabs when preparing squared test cants from logs.

The complete installation is shown from the tail side of the mill in Fig. 10. The extension of the hose inlet in the cleaner tank, and the bag tied to it, are shown in Fig. 11. The extension inlet consists of a short length of molded auto radiator hose with a 90 degree turn. Two to three inches of straight hose on both sides of the turn will provide space for attaching the bag and for mounting on a sheet metal plate bolted to the

Fig. 8.—Spillage pickup installed on a 6-foot band mill.

tank wall around the regular inlet. A ½-inch-wide sheet metal sleeve cemented inside the bag end of the hose with rubber gasket cement is desirable to prevent deformation of the hose when the bag is tied in place.

The action and operation of the pickup are simple. Prior to a test run, the vacuum is turned on for a short period, with no collecting bag in place, to clean out the system. A weighed collecting bag is then tied in place, the vacuum cleaner is turned on, the test cut is made, and the spillage is collected and weighed. If the saw or material used tends to produce splinters at the bottom of the cut, such splinters should be picked out prior to weighing.

Test runs were made with red oak logs in order to test the selectivity of the pickup, to be sure that sawdust was not being drawn from the gullets by the suction, or that spillage dust was not being missed. The large quantity of tannic acid in unseasoned red oak reacts rapidly with clean, oil-free ferrous metals to produce the dark, blue-black iron tannate commonly seen on both wood and tool when an ax or saw is left in contact with wet oak.

The time the particles are in the gullet is too short to produce noticeable coloration, because the sawdust is only carried about 4 feet, in about 0.02 to 0.03 second, before it leaves the saw. Spilled sawdust, however, quickly loses most of its downward velocity in the clearance space between the moving smooth blade and nearly stationary rough kerf wall.

As the spilled particles work their way down between the blade and kerf wall, contact with the steel continues until the particles reach the bottom of the cut, or until the feed of the cant carries the particles horizontally beyond the back edge of the saw. The duration of contact depends, of course, on the cant feed, rate of particle fall between blade and kerf wall, the width of the saw, and the height above the bottom of the cant at which the particle escapes from the gullet. The color acquired by the particles is not only that produced directly in or on the wood by the reaction, but also that acquired by rubbing off coloration formed on the steel.

Color intensity might be expected to decrease with an increase in feed rate, since the feed distance from the front to the back edge of the blade is covered more rapidly, and reaction time is reduced. This reduction in intensity was obtained, but the lightest shade was still quite dark, as is apparent even in the black and white of Fig. 12, in which the colored spillage dust (B) is compared with the natural-colored sawdust (A) carried out in the gullets.

With the color-tagging thus achieved, the selectivity of the vacuum pickup could be evaluated readily. By placing a clean box in the proper position in the sawdust pit, with the exhaust system off, all sawdust not caught by the spillage pickup could be collected for examination and comparison with that in the collecting bag of the pickup.

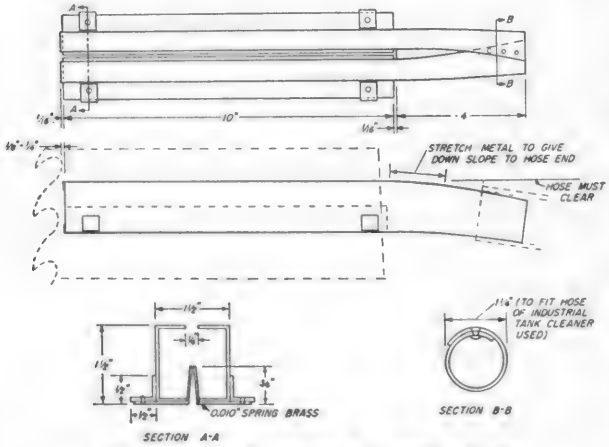

Fig. 9.—Dimension drawing of spillage pickup.

Fig. 10.—Spillage pickup and vacuum tank as viewed from tail side of mill.

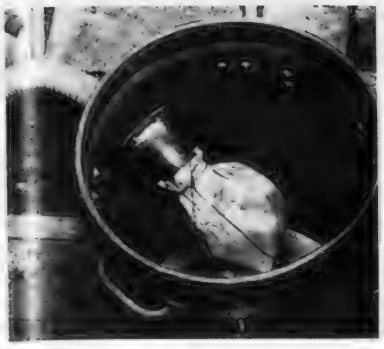

Fig. 11.—Sawdust collecting bag attached to hose extension within the tank of an industrial vacuum-cleaner unit.

Fig. 12.—Natural-colored red oak sawdust (A) carried out in the gullets, and blue-black spillage sawdust (B) stained by the reaction of the iron saw with the tannic acid in the sawdust as the spillage particles worked their way down between the blade and kerf wall.

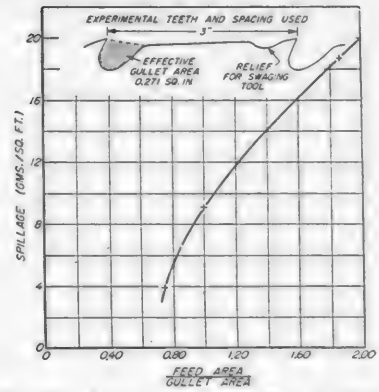

Fig. 13.—Relation between spillage sawdust and feed rate.

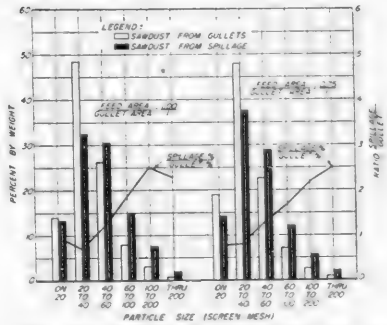

Fig. 14.—Particle size distribution in sawdust from the gullets and spillage.

Examinations of such separate lots of sawdust showed no tannate-colored particles in the sawdust carried out by the gullets, and no particles of natural wood color in the sawdust picked up by the vacuum spillage pickup. The 100 per cent selectivity thus indicated may not be obtainable with all saws and cuting conditions, but a selectivity of at least 95 per cent might be expected under all reasonable conditions. The sawing process itelf contributes to the separation, since the reduced downward speed of spilled dust and the horizontal movement of the cant act together to discharge spillage particles some distance behind the line of the gullet bottoms.

The principle of the spillage pickup is applicable to circular saws as well as band saws. The pickup may be either in the form of long tubes that extend along the saw at collar height and join beyond the saw, or two short pickups, one at each side of the saw, each fitted with a branch hose to the main vacuum hose.

The spillage pickup cannot be expected to collect *all* the sawdust spilled from the gullets because, as previously mentioned, some sawdust particles are lodged in the irregularities in the kerf walls and do not work out of the kerf during sawing. This lodged spillage can be collected separately, preferably by a vacuum cleaner arrangement. Increased sidewise pressure due to packing in the gullet tends to concentrate the lodged spillage near the bottom of the cut.

Maximum information will be obtained on quantity and distribution when the lodged spillage is cleaned off in several strips paralleling the edges of the cut faces. This cleaning should be gentle to avoid the breaking loose of fibers still attached to the cut surfaces.

In addition to the lodged spillage dust, the quantity of adherent or partly detached fibers and bottom splinters may be determined. After vacuum removal of the lodged dust, a vacuum cleaner nozzle with an attached scraper edge may be used to break free and collect the adherent fibers. The scraper should not be so sharp or vigorously used, however, that fibers from the solid wood will be scraped off. Removal in parallel strips may be desirable to find out whether the gullet packing near the bottom of the cut removes adherent fibers by scouring, or, on suitable boards, whether a change in grain angle, from flat to edge, has any effect on fuzziness or wooliness.

Some pilot tests with the vacuum spillage pickup were made on a 6-foot band mill at Michigan State University. An experimental, 10-inch, 15-gage (0.072 inch) saw blade was fitted with small teeth swaged to 0.125 inch, spaced 3 inches apart, and with a gullet area of 0.271 square inch. This is the blade visible in Fig. 8 and profiled in Fig. 13. The long tooth backs were provided for subsequent lengthening and deepening of the gullets during the test series.

In the pilot tests, cuts were made in a red oak cant with a cutting-face width of 12¼ inches. Feed rates were 0.04111, 0.0221, and 0.0166 inch per tooth. The spillage sawdust, in grams per square foot of kerf, is given in Table 1.

A curve of spillage sawdust over feed rate, with feed expressed as a ratio between solid wood area and gullet area, is shown in Fig. 13. This curve is only tentative, since data are needed to isolate the effects of lineal feed per tooth, side clearance, adherence of sawdust, and other factors. It does indicate, however, that spillage drops off sharply as the gullet load decreases, despite the smaller particles produced by the reduced bite per tooth.

The distribution of particle sizes for spilled sawdust and that carried out

Table 1.—EFFECT OF FEED RATE ON AMOUNT OF SPILLAGE SAWDUST

Feed per tooth		Gullet area Sq. in.	Solid wood area ÷ gullet area (GFI)	Spillage sawdust Gm. per sq. ft.
Lumber	Area Sq. in.			
0.0411	0.503	0.271	1.86	18.7
.0221	.271	.271	1.00	9.1
.0166	.204	.271	.75	3.87

Table 2.—SAWDUST PARTICLE SIZE DISTRIBUTION AT TWO GULLET FEED INDEXES

Screens		Sawdust retained on screens			
		1.0 GFI		0.75 GFI	
Mesh No.	Size of opening In.	Gullet Percent	Spillage Percent	Gullet Percent	Spillage Percent
20	0.0331	14.0	13.4	19.0	14.2
40	.0164	48.3	32.3	48.0	37.6
60	.0098	26.2	30.4	22.6	28.7
100	.0059	7.8	14.8	7.1	12.0
200	.0029	3.0	7.5	2.5	5.5
Passing though 200-mesh		.7	1.6	.8	2.0

by the gullets is shown in Table 2 and Fig. 14 for two feed rates.

In Fig. 14, the curves superimposed on the bar charts show the ratio of spillage sawdust to gullet sawdust in each size class. These curves show that the larger particles are less frequent in the spillage than in the gullet dust, whereas the relative frequency of fine particles in the spillage increases as the particle size decreases. At the faster feed (GFI = 1.0), however, the larger particles, those held on the 20-mesh screen, are nearly as numerous in the spillage as in the gullet dust. It is possible that the greater degree of packing forces the larger particles against the kerf walls where they escape from the gullet when they happen to lie flat against the kerf surface.

A siginificant feature of these larger particles, however, is the structural difference between the spillage particles and those carried out by the gullets. The gullet particles (Fig. 12, A) show the expected cross-sectional surfaces and transverse shear planes, together with the bending and crumbling that result from tight packing.

In contrast, practically all of the larger spillage particles (Fig. 12, B) were flat, uncurved flakes, cut parallel to the grain, that obviously were shaved off by the side edges of the teeth. Such side cutting would tend to permit these shavings to enter the side clearance zones, which, in this case, were 0.026 inch per side. Flake thickness ranged from 0.005 to 0.015 inch, so that clearance was adequate for properly positioned flakes.

The side cutting that produces such shavings could occur at the top of the cut if the saw vibrates above but not far into the cut, or at any part of the cutting face if the saw is overloaded and wanders from a true cutting line. Such flakes could also be produced by teeth that are out of line or not shaped and ground to uniform width. In these sawing tests, deflection under the severe loading probably accounts for the large flakes.

The particles held on the smaller meshes showed no readily discernible consistent differences in cell orientation, although the "through 20-on 40 mesh" class appeared to have a higher proportion of fine and comparatively long slivers with longitudinal cells in the spillage. These slivers passed end-

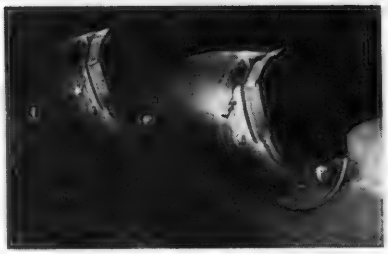

Fig. 15.—These two teeth were coated with blue layout lacquer. After a short run, the abradable material was worn mainly in a band about as wide as the flange.

wise through the previous screen openings.

In the fraction that passed through the 40-mesh screen, most particles, both from gullets and spillage, were slim rectangles with a length of about 2 to 6 times their narrow dimension. Cells were longitudinal in practically all of these, since the mesh openings were smaller than the length of the particle.

The particles that did pass were thin shafts of a few cells each that were split from the chip in the cutting or during the subsequent churning and packing in the gullet. The rubbing off of partially detached fibers would add additional slender particles that would be most likely to appear in the spillage. The 40- to 60-mesh fraction of the spillage dust did show a high proportion of slender particles with broken ends, rather than the cut ends that predominate in the corresponding fraction of the gullet sawdust.

Although much information on sawdust action can be gleaned from the appearance of the particles, the amount of spillage carried out of the cut, and from the amount of adherent and partly detached fibers, the proper design of gullets requires further information on sawdust movement. The motion of sawdust as it accumulates in the gullet, the points of escape from the gullet, and the subsequent path of spillage dust are important to gullet design.

Escape of sawdust may be studied by coating the blade with an easily abradable material, such as the blue layout lacquer used on the two teeth shown in Fig. 15. Lacquer was applied to the front of the teeth and holders, and to the sides of the holders, teeth, and sawplate from the bottom of the tooth sockets to the rim. After a short run at less than full gullet capacity, the lacquer appeared to be worn in bands. Wear was moderate from the rim to the top of the flange on the holder. A still lighter shade of blue, which showed greater wear, formed a band nearly as wide as the length of the flange. The dark blue below this band indicated little or no abrasion.

The toughness and possible tackiness of the lacquer, if it becomes warm, reduce its ability for showing up the sawdust movement. A thin copper plating would be more desirable, because it could not become sticky and the color contrast would be adequate. Deposition of copper, either by replacement from a chemical solution or by brush electroplating, could be accomplished readily. A suitable solution is 11 grams of copper sulfate, 2.2 grams of ferric chloride, and 1.7 cubic centimeters of hydrochloric acid in 100 cubic centimeters of distilled water.

Sawdust escape also may be studied by high-speed photography, although the greatest value of such photography lies in the information it gives on sawdust movement within the gullet. Studies along such lines have been made by Endersby[6] in England, and by Englesson, Hvamb, and Thunnell[7] in Norway and Sweden. Thunnell used plexiglas disks on each side of the saw. These disks rotated with the saw as it cut stock of the same thickness as the saw teeth. His method does provide some record of movement, rather than instantaneous position of the sawdust particles. Sawdust action is a difficult subject for photographic study, but with improved techniques in working at normal saw speeds, the results obtained will be free of distortions that might be present when the saw is slowed abnormally, stalled, or abruptly stopped.

Improved photography of sawdust chambering, coupled with abrasion-sensitive coatings and means for measuring sawdust spillage, will provide a good idea of what is happening at the cutting edge of a saw. Such information will be invaluable in designing saw teeth for such problem conditions as abrasiveness, fuzzing and other grain conditions, and the sawing of frozen timber.

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[6] Endersby, H. J. 1953. The performance of circular plate ripsaws. Dept. of Scientific and Industrial Research, London, Forest Research Bul. No. 27.

[7] See footnote 4.

Prefabricated Dry Kiln Buildings[1]

RICHARD H. ELLIOTT
Vice-President, Standard Dry Kiln Co., Indianapolis, Ind.

Prefabricated dry kiln buildings are reported to have greater insulation value than conventional masonry construction, resulting in steam economy and greater drying efficiency. Less maintenance is needed as there is little or no condensation, a major cause of trouble in masonry kiln buildings. Other advantages include cost, which is competitive with conventional types, and the ease with which the building can be moved if necessary.

THE NEWEST DRY KILN buildings are the insulated, aluminum-paneled, prefabricated kilns which have gained wide acceptance throughout the country in the woodworking field.

Prefabricated steel and aluminum buildings are being produced by a number of firms. Their advantages over any other construction are closely aligned with our particular insulated kiln building. The word prefabricated merely means that the structural steel work and siding are mass produced in a factory and later assembled on the job. An outstanding example of this is the skyscraper in New York City which was completely sided in one day with aluminum panels and which probably would have taken a month or so with conventional siding.

The same thing holds true in kiln buildings. All of the wall and roof panels are completely constructed and the steel work is cut, welded, and drilled for very close tolerances in the manufacturer's plant. It may then be assembled with a minimum of trouble in the field by rather inexperienced labor, with or without the supervision of one of the manufacturer's installation men.

Advantages of Prefabrication

The natural question often comes up as to why these prefabricated buillings were started. Are they cheaper? Are they of better construction? What are the advantages? Let's look at the construction first.

The aluminum wall and roof panels are each built as a complete aluminum envelope with an insulated core and are completely vapor proof. This is accomplished with the use of explosive rivets pulling the aluminum sheets tightly together against moisture-proof gasket material.

The test of any insulation is its ability to stay dry and maintain its full insulating value. The side walls of the building are equivalent to 27 inches of common brick in insulating value. The roof panels are equivalent to over 41 inches of brick in insulation value. An obvious advantage of a prefabricated kiln is that, in comparison with a well constructed masonry building, it saves 50% of the steam normally lost in radiation through masonry walls. This can result in real dollar savings per thousand board feet in steam economy and greater drying efficiency.

Other advantages as far as the construction is concerned are that once this building is constructed, there is no painting or plastering of walls or continual maintenance as is necessary on conventional masonry construction.

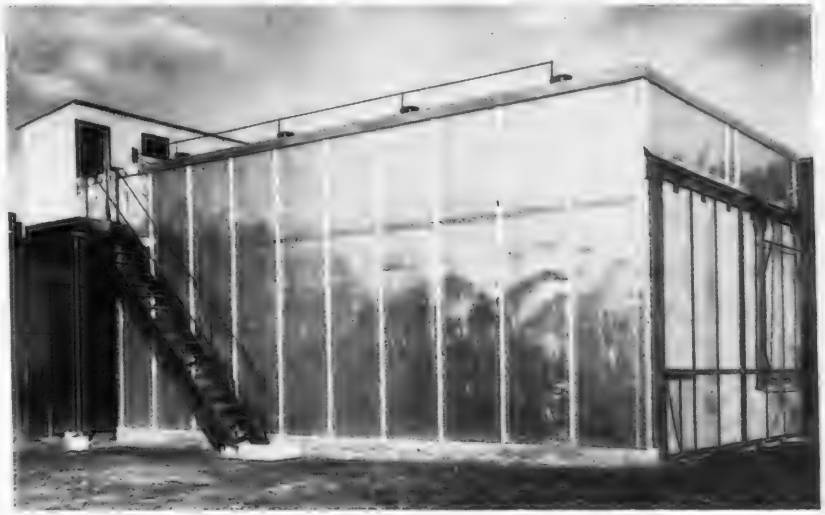


Fig. 1.—Prefabricated, internal-fan compartment dry kiln.

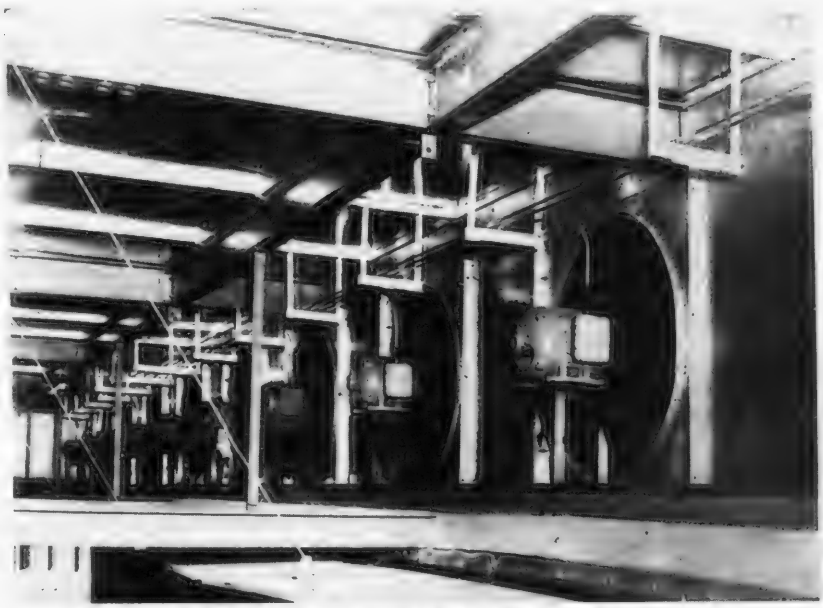


Fig. 2.—Battery of internal fans in prefabricated kiln.

[1] Presented at meeting of FPRS Ohio Valley Section, Oct. 14-15, 1954, in Louisville, Ky.

Fig. 3.—Interior view of double-track prefabricated unit, with fans located overhead.

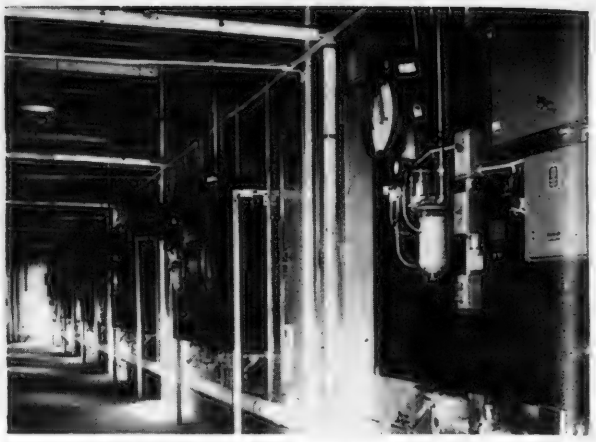


Fig. 4.—Control room showing instrument panels for battery of kilns.

Continual maintenance is a task that is certainly not a pleasant or inexpensive one in masonry kilns, but a very necessary one if the building is going to hold up. Prefabricated kiln walls are designed so that with a relative humidity inside the kiln of 85% and an outside temperature of 0°, there will be no sweating on the walls or steel work. This condensation causes the majority of trouble in kilns today.

What about the question of cost? Experience over the country, ranging from as far north as Maine to Georgia, shows that in most cases prefabricated kilns are competitive to good masonry construction. Particularly in larger industrial areas, many times prefabricated kilns have been lower than masonry construction. The latter refers to the conventional block and brick building with a well insulated roof, but certainly this masonry building would not compare with the insulation value of the prefabricated kiln. It would be commercially impossible to build a masonry building with as much insulation value as it is possible to obtain with aluminum construction.

The manufacturer can mass produce these aluminum insulated panels, most of which are a standard size of 4 x 12 feet, so as to reduce the overall cost of the building considerably.

What are some of the other advantages of these prefabricated buildings? One is that, for the first time in the history of dry kilns, it is possible to salvage not only the equipment but the building itself if the operation should ever be moved or the drying operation should ever be discontinued. If dry kilns were thought of as another woodworking machine in the plant, then this would come to mind immediately. Actually woodworking machinery has one of the greatest returns of any type of machinery today as far as trade-in value or value of the used machine itself. There are many vacant kilns around today where a considerable investment in block and brick and cement and mortar will realize very little or nothing for the owner.

Thus one of the big advantages of the prefabricated kiln building is its ability to be taken down and moved to a new site or sold as a complete package unit. Recently two 40-foot kilns sold in 1951 in Virginia were moved to New England with a minimum of trouble and a good return of the original purchase cost.

As an example of the waste sometimes connected with masonry buildings, it was recently necessary at the Newport News Shipbuilding & Dry Dock Company to tear down six of their masonry buildings to allow for expansion of their shipyard. Rather than go to the expense of putting up masonry buildings, they decided it would be better to put up three 52-foot prefabricated buildings so that if the necessity of moving should ever come again, their only loss would be in the concrete footing and not in the complete building itself.

Another place where prefabricated kilns seem to be particularly popular is in the sawmill business where they have a limited timber supply and plan on moving their sawmill site within a few years. Another where the prefabricated kiln has come into use is where the prebricated building is put inside of another structure for use close to the production line. These are usually smaller units. The ones down at the Norfolk Naval Shipyards, for instance, are approximately 50-foot and have men working very close to these units which have little or no heat loss.

Prefab kilns are completely flexible as to size. Small units have been built for educational and experimental purposes in universities and plants, and large units 104 feet long were recently installed at a new furniture plant in Pennsylvania. Recently completed was an installation of eight 40-foot prefab kilns which replaced kilns of wooden and masonry construction at a chair plant in New York State.

Another question that comes into the mind of the prospective buyer is what about the life expectancy of these buildings. The materials that go into the manufacture of this building have been used by dry kiln companies for over 30 years in the manufacture of kiln doors. By using the finest aluminum and the heaviest gauge practical, it is known that this material will withstand the conditions inside the kiln indefinitely.

The use of all aluminum bolts, and the fact that at no place in this building does aluminum touch steel, insures that there is no chance of electrolysis. There is an air space all around between the aluminum side wall panels and the steel structure itself. The wall and roof panels of the kiln building are pulled up tight against aluminum extrusions which have gasket material attached to provide a completely vaporproof wall or roof.

The question has come up regarding damage to a wall panel. These panels can easily be removed and a new one inserted, or the aluminum can be effectively patched, using aluminum explosive rivets.

Finally, another one of the most attractive features of this prefabricated construction is that the customer knows within a few dollars what his exact cost is going to be before he enters into any project of this type. He is given as close to a lock and key job as is possible in dry kilns. The units go up easily and quickly and the customer's operation is not interrupted for any length of time. The entire responsibility for the building is up to the dry kiln manufacturer and the buyer knows that he is getting the finest construction possible at the lowest possible cost.

The Choice of Barker for the Sawmill[1]

PANEL DISCUSSION

Factors affecting the selection of a sawmill log barker were discussed by a panel representing mills using five current types of hydraulic or mechanical barkers. Speakers covered installation, operation, efficiency, maintenance, and related factors.

THE FOLLOWING DISCUSSION followed an all-day tour by meeting attendees, to inspect barking and chip-handling facilities of five representative mills in the Vancouver area. Discussion moderator was Paul Heller, Technical Manager, Pacific Pine Co. Ltd., New Westminster, B. C.

Mr. Heller: The large attendance on the plant tour denotes the interest in log barking at the sawmill. Panel members were selected because of their experience with barkers used at the mills they represent. Some of them have worked in developing the prototypes of the present barkers and are familiar with the history of the machines, their performance, advantages, and shortcomings.

The Nicholson Mechanical Barker

D. G. ALLISON

Manager, Lions Gate Lumber Company, Ltd.

Introduction

Before dealing directly with the problem of mechanical barkers, a few figures relating to this plant are pertinent:

(1) Maximum log length—24 feet
(2) Production — 75,000 F.B.M. (B.C. Log Scale) per 8 hours —operating two shifts a day
(3) Species—fir and hemlock (fir predominant)
(4) Power—Steam, 400 h.p. Electric, 1600 h.p.
(5) Basic Equipment—9 ft. band head rig and #18 Wickes cant gang saw.

The progress in barking equipment had been noted for several years. It was apparent that the high-capacity hydraulic barkers being installed in the pulp plants and large mills were not economically feasible for this size of operation. About two years ago the Nicholson mechanical barker was observed at a time which coincided with the development of a suitable market for pulp chips in the species being cut in our plant.

Requirements and Investigation

The immediate concern regarding the Nicholson barker centered around the following points: (1) Capacity; (2) Performance; (3) Cost. Satisfaction as to the capacity and performance of the machine was obtained by studying the operation of two similar machines operating in the State of Washington. The machine appeared to be of adequate construction to stand the abuse of west coast sawmill practice. The operators visited expressed general satisfaction with the performance of their mechanical barkers, after making due allowances for the pioneering done with the first machines manufactured by the Nicholson Company. The cost of the Nicholson Barker, while substantial, was considerably less than any other type of barker of comparable capacity available at that time.

The only other barker seriously considered was a Hansel oscillating barker, generally referred to as a Wig–Wag barker. At the time of this study the Wig–Wag barker was a comparatively new development, and to our knowledge was not yet in use in any sawmill in this area. This Hansel machine, although of less cost and capacity than previously available hydraulic barkers, still presented some serious problems for operation in our plant. The high power requirements far exceeded available plant capacity and would have necessitated a costly new primary power service and electrical distribution system. The other serious drawback, in our opinion, would have been the problem of water-saturated bark, which would have caused further substantial expenditures in our plant.

About this time the need for the pulp-chip income was beginning to be felt. Consequently the decision was not to await further barker development, but to proceed with the pulp chip program, using the Nicholson barker. An order for a 50-inch Nicholson Roto Barker was placed in July, 1954.

Location of Barker in Sawmill

The location of the barker in the sawmill operation appeared to be an important question. Most of the plants visited favored a separate barking mill, or at least the ability to return barked logs to the log pond as a reserve in case of breakdown. It was estimated that the cost of a separate barking mill would be not less than $30,000. Since the "in-line" type of installation was favored, the machine was placed in the log conveyor just before point of delivery onto the log deck. The advantage of having a barked log reserve was outweighed by the much cheaper cost of installing "in-line", and more important the saving in operation manpower. It was found that with the installation of the barker the log-deck was not required, so the only increase in labor cost was the difference in rates of pay between a log deck man and the barker operator.

Another basic reason for installing our machine in-line was that we believed a properly constructed and maintained machine should be just as reliable as, say, a band mill or gang saw. Therefore a separate barking mill did not seem justified.

Installation

The machine installation was effected without interruption to the mill production. The project was planned in three stages. On the first week-end the log conveyor section was removed. The main barker frame was lifted into place, being mounted on a larger sub-frame consisting of 20-inch 'I' beams, 40 feet long. This sub-frame made possible the week-end installation and also provided an adequate tie-in between the log conveyor and the log deck. The infeed and outfeed chains of the barker were synchronized with the log conveyor and operated as a unit until the barker installation was completed.

The second stage involved the week-end installation of the barker side frames and additional electrical and air equipment.

The third stage simply required the fitting of the barker ring proper and connecting the controls for the barker operation. The barker started operations in December, 1954 and has worked continuously two shifts a day, to this time (October, 1955).

[1] Presented at meeting of FPRS Pacific Northwest Section Oct. 25, 1955, in Vancouver, B. C.

Cost of the barker installation was as follows:

50-inch Nicholson Barker (including tax)	$ 79,000.00
Sub-frame	5,000.00
Materials and auxiliary service—including electric motors, panels and air compressor	23,000.00
Labor	4,000.00
Total	$111,000.00

Production, Yield, Saw Cost

Since the barker installation, average production has increased approximately five to seven per cent. It is difficult to be sure just what effect the barker operation has had on sawmill yield. In the past ten months the quality of logs and the percentage of species have varied considerably over previous periods, making a comparison difficult. Average yield has improved slightly in the last ten months in spite of a much higher percentage of hemlock cut in the mill.

In the past ten months saw cost has been reduced approximately twenty-five per cent, believed to be due directly to the barking operation.

Maintenance

Admittedly this machine has operated only ten months so possibly our experience cannot be seriously considered. To date, however, there have been no major breakdowns, and a minimum of time loss. The barker operator greases and lubricates his machine and the regular millwright crew maintains it. Oil consumption is half a gallon per 8-hour shift. The only possible flaw of which we are aware is in the quality of the outfeed chains. Although our chain has not caused trouble to date, other machines are known in this area where the chain has been replaced at periods varying from eight to twelve months after the start of operation. It is understood that these chains are being replaced after failure with a manganese chain of similar construction, and that all new machines are coming out of the factory so equipped.

Log Cut-Off Saw

A development of some interest is our method of bucking logs. With a 24-foot mill it is obvious that a very high percentage of the logs delivered to the mill require cutting to length. Heretofore this has been done by power drag saw in the mill pond. For some time this method was believed costly as well as adding to the congestion of the log pond. In July of this year an experiment was carried out by installing a chain cut-off saw between the outfeed chain of the barker and the log deck conveyor. The chain saw is operated with push-button and air cylinder control by the barker operator. It has been found that the time lost in making the cut-off is made up by the otherwise more continuous barking of longer logs. Apart from more accurate log lengths, the log cut-off operation is being accomplished with three less men than required by the previous method. The pond saw is retained for the occasional bucking of an excessively crooked log and for logs exceeding 60 feet in length.

Conclusion

If re-ordering a barker today, the purchase would be substantially the same with the possible exception of ring diameter. We have experienced in the past ten months a somewhat higher percentage than originally anticipated of logs too great in diameter for the barker. Some of these logs could have been barked with the 60-inch barker. To date, however, the very active peeler log market has absorbed these sort-outs without difficulty, and at greater economic advantage than processing them through the sawmill. We believe that in the future the average log diameter available to our type of mill will decrease and that the 50-inch barker will meet requirements completely.

Simons rotary head barker. Logs are moved into barker at left, debarked logs transferred to conveyor chain at right.

The Simons Rotary Head Barker

G. S. G. BOWELL

General Manager, Canadian White Pine Division, MacMillan and Bloedel, Ltd.

Installation of the Simons 36-inch Rotary Head Barker for the small log mill began in 1948. It was the first unit of its type, and was strictly experimental. Experimentation and changes continued over several years.

The objective was to develop a new barker that would overcome certain problems of two alternative machines, the Hansel ring barker and the Bellingham barker.

The former was being developed in a Port Alberni sawmill and was still in the experimental stage. Difficulties were being experienced with the seal between the spinning and the stationary portions of the ring. It was believed that both the sediment-laden Fraser River water at the Vancouver mill, and the salt water at the Chemainus mill would cause even more trouble.

The second barker was considered very successful on large logs but there was some doubt as to its ability to bark small logs because of the lack of a holddown device. Also the Bellingham barker was believed to lose relative capacity on logs below 12 inches diameter because production is strictly on a lineal rather than a volume basis. This barker requires a full-time operator. Because of its weight it requires a heavy-duty structure, and therefore a higher installation cost. It needs more space than an in-line barker, an important consideration in this instance.

Advantages

The Simons barker had the following advantages:

1. Clean barking — 95 per cent of the logs were clean after one pass.

2. High capacity on small logs. A movable head was developed to lower on small logs and raise on large logs. Small logs can be passed through two at a time. The barker can handle 15 Mbm per hour as a reasonable average.

3. Low installation cost of $17,000 including costs of trial installations

but excluding the cost of steam. The latter requirement is 15,000 lb. per hour. This is an in-line barker requiring less space than the Bellingham type.

4. River water was found satisfactory and is available at low cost.

5. Maintenance cost has been very low, averaging $650 per month over the past year, including one major head removal.

6. One man supervises log deck and barker (whose operation is automatic and continuous), and operates the cut-off saw.

Disadvantages

1. The upper log diameter limit is 33 inches; logs over this size must go to the large log mill.

2. Barking of cedar is too slow due to the necessity of shutting down five or six times each shift in order to remove the cedar bark wrapped around head, rolls and other parts. (Corrected in larger and later models).

3. A run-around is required to ensure completely clean barking. Reversible rolls are not an alternative in this installation as this would reduce barker capacity below mill requirement. About 5 per cent of the logs are not completely debarked. A run-around is considered necessary for all barkers but the Bellingham, if these barkers are producing near capacity.

Simons 60-inch Rotary Head Barker for the Large Log Mill 1953

By the time the large log mill was ready to select a barker several other sawmills had acquired experience with a large Simons barker. Both the Nicholson mechanical and Hansel wig-wag barkers were still experimental at this time. The pulp mill specifications for chips required complete removal of bark and cambium. The Nicholson barker was discounted slightly due to difficulty in removal of bark around knots, especially on rough tops, and in the flutes. Cedar bark, especially, is not wanted in the pulp mill.

The Simons barkers had given low maintenance costs, considered as better than those of the Nicholson or the Hansel ring barkers. The latter could not use unfiltered water whereas the Simons machine could, resulting in a major saving in capital cost.

At the time of the choice the Hansel wig–wag barker had the following problem:

(a) Using the log haul for the barker infeed gave a one-pass operation. Some logs would not be clean so that there would be an added cost in returning them to the log pond.

(b) If the log haul were equipped with variable speed there was some concern that slow-barking logs would delay the head rig. (This has not been borne out in practice).

The Bellingham barker was rejected basically because its capital cost was considered to be $150,000 to $200,000 more than the Simons.

The operating experience with the Simons 60-inch barker has been very satisfactory. Down time has been negligible. Maintenance costs have been low (approximately $1000 per month) including one head overhaul per year. Barking has been clean, with time to return up to 60 per cent of the logs barked for a second pass, if necessary. Loss of fiber due to tearing has been negligible. Rough tops and fluted butts have created no problems. Production has averaged 25 Mbm per hour with 30 to 40 per cent of the logs making three passes.

A disadvantage is that 0.5 per cent of the logs must be by-passed due to size. To get completely clean barking a percentage of the logs must be returned, or two additional side heads installed, as in another Simons machine. The necessity of returning logs reduces the capacity of this barker to something below the Bellingham barker, and a slight amount below the Hansel ring barker.

The Simons barker has approximately 10 to 20 per cent higher water usage than other barkers. It also has a higher power requirement. Where the Bellingham barker required 1500 h.p. turbine capacity the Simons required 1800 h.p. A higher capital investment was required than with the Nicholson mechanical or Hansel wig-wag barker. It has a lower installation cost than the Bellingham barker. On one recent typical example a Bellingham barker would have cost only $10,000 more, on a $300,000 installation; but at another mill the Bellingham would have been $150,000 to $200,000 more.

For a total cost of $400,000 and a steam requirement of 20,000 lbs. per hour this barker produces an average of 0.74 units of chips per Mbm sawn.

In general, the main advantages of the Simons barker are:

(a) low operating and maintenance costs
(b) can be installed on timber construction
(c) requires a minimum of space
(d) long logs present no problem of added cost
(e) rough tops and very small logs are no problem
(f) fiber losses are minor

The general trend in barking development is toward complete cleanness and minimum of wood loss. The Simons barker compares very favorably in both these all-important factors.

The Hansel Oscillating (Wig-Wag) Barker

F. S. FOYSTON

Mechanical Superintendent, Alaska Pine and Cellulose, Ltd.

Introduction

Every installation has its own problems and limitations peculiar to the mill layout, geographical location, flow plan, and so on. This is a 20-foot mill cutting 800 logs and 140 Mbm per shift, on a two-shift operation.

Our mill has had a history of barking experience originating just after World War II when one of the first slab barkers in the area was installed. This barker was modified and altered many times. In its final form a camelback type of chain conveyed the slab beneath four fixed jets of water impinging at right angles to the slab from above. Recovery with this unit, plus material from the mill without bark, amounted to 0.4 units of chips per 1000 fbm log scale. Water pressure was 1500 psi at a volume of approximately 500 US gpm.

Log Barker Study

Prior to 1951, not much serious thought was given to a log barker at that particular division because the slab barker was fairly successful. During 1951, however, we studied the engineering aspects of both the Bellingham barker and Hansel ring barker in regard to the Universal Lumber and Box Division mill. Because of the very limited space available, it was not economically feasible to install either barker. Further study was given to a ring barker mounted on a large scow. Again, space was at a premium and the installation on a scow at that time seemed to be largely experimental and

Hansel oscillating arm barker in operation at Alaska Pine Co., Ltd., New Westminster, B. C.

not attractive economically. The whole matter was consequently held in abeyance until the early spring of 1953. At that time we embarked on an experimental series of tests in conjunction with the Hansel Engineering Company, on an oscillating-arm, slit-nozzle type of barking device.

This unit, which was mounted on the log haul to bark the top half of the log, consisted of a motor and reduction unit driving a tapered arm on the end of which was mounted a nozzle plate 4–¾ inches long and .057 inches (i.e. 57 thousandths of an inch) in width. Water was delivered to the arm by a hose and rotating joint. Speed of the log haul was made variable for the test period by the use of a wound rotor motor. A number of logs were tested over a period of approximately a month. These logs were carefully varied in size and species. We were particularly careful to choose very hard-barking logs which were available at that time of year.

From carefully tabulated results it was estimated that a log barker incorporating two such arms, one mounted on each side of the log, would give the required barking results. However, to assure 360 degree coverage of the log by the jets, it was considered necessary to mount the nozzles so that their jet streams would overlap on the bottom of the log. A small top oscillating nozzle, therefore, would have to be mounted on the top hold-down roll to bark a strip of the log approximately 12 inches wide. This nozzle was to measure 1–¾ inches by .030 inches.

Because the side nozzles would have to remain a fixed distance from the centerline of the log haul, the most difficult barking was to be expected on very small, hard-barking logs. To add to the problem, these logs would have had to be fed through the barker at a log haul speed of approximately 65 feet per minute. The top nozzle, because it was to be fixed to the hold-down roll, would remain at a constant distance from the log, regardless of log size. This nozzle later proved to be both effective and necessary. Thus the total water required by the log barker was calculated to be 875 US gpm at 1500 psi, 400 gpm being supplied by each of the side nozzles and 75 gpm by the top nozzle.

At this point, the economics of log barking were again carefully studied. An analysis, lacking in certain details, is presented below.

For a two-shift operation, based on an increased recovery of 0.2 units/M log scale (above a slab barker recovery of approximately 0.4 units/M) and an annual cut of approximately 70 million fbm, with chips worth about $15.00 per unit, the annual increase in income was estimated to be:

70,000 Mbm, or 14,000 units at $15/unit		$210,000
Save 4 men in 2 shifts = 8 men @ $3500		28,000
1/3rd of Saw cost (headsaws)		2,000
Gross Savings		$240,000
Less		
Additional power	$23,000	
Additional maintenance	7,000	
Amortization	20,000	50,000
Annual increase in income before taxes		$190,000
In additional, we expected an increase in overrun of at least 1%, equal to		$ 50,000
Quality improvement		7,000
Total increase		$247,000

Grade improvement, increased cut, reduced housekeeping costs, not to mention a much safer operation, are other benefits to be obtained.

Final Design and Performance

Because the benefits were calculated to be so great, and because test results were so satisfactory and encouraging, steps were taken by the manufacturer, Hansel Engineering Company, to design and install a barker incorporating the features of the test unit with, of course, many refinements.

In the estimate, total cost of the installed barker was considerably less than the annual increase in income. We must remember however, that on this particular installation, part of the pumping system along with the chipper and some of the screening facilities were already in operation.

The barker consists mainly of a large housing on the log haul, two nozzle arms operated by a vari-stroke unit which controls the length of stroke, a hydraulic drive to control the speed of oscillation of the arms, a hold-down roll upon which is mounted the top nozzle, and which controls the "master and slave" hydraulic system. This system controls, in turn, the length and speed of stroke, and the speed of the log haul. The hold-down roll, because it rides on top of each log, "tells" the log haul at what speed to move the log, and "informs" the arms to move faster or slower, with longer or shorter strokes as the case demands. For instance, a small log is taken through at a high speed, but with short quick strokes of the arms. Conversely, a large log goes through slowly, with long slow strokes of the arms.

The barker was first started on February 1, 1954, and despite the usual "teething troubles" inherent in a prototype, operated 58 per cent of the time in February. We did experience considerable difficulty at first with rotating joints, failure of arms, excessive wear on nozzles, and breakages in the vari-stroke unit. However, in a matter of several weeks all troubles were ironed out, and the barker has operated almost continuously since without lost time. Routine preventative maintenance on nozzles, rotating joints, vari-stroke unit, etc., is of course, necessary, as with all equipment.

Subsequent operation of the barker proved that the quantity of water provided, 875 gpm, was considerably in excess of that required for a daily cut of 140,000 fbm. On easy barking logs, only half that capacity was used for periods extending to two weeks at a time. Furthermore, to reduce water consumption to a minimum, nozzles were progressively reduced in size until a minimum of 4 inches by 0.44 was used on the side nozzles and 1–¾ inches by .022 on the top, for a total log barker water consumption of 580 gpm. The actual chip recovery was 0.26 units per Mbm over the slab barker yield of 0.4 units.

In closing, I would like to say a few words about the cost of barking logs with this unit using two alternative sources of power, i.e., electrically driven and turbine driven pumps. Based on a ten year amortization, and the pumps driven electrically, costs were approximately as follows:

Electrically Driven Pumps:	
1. Amortization	$21,000
2. Electrical power	32,000
3. Operator	7,000
4. Maintenance—Labor and Material	6,000
5. Pump repairs	4,000
	$70,000

This amounts to approximately $1/M based on an annual cut of 70 million per year.

Turbine Driven Pump: The investment is somewhat more, and therefore so is the amortization figure. All other charges are the same, except the $39,000 ($32,000 plus $7,000) which with a turbine is saved by recovery of exhaust steam, an operation costing little. Consequently, the cost of barking works out to about 60¢/Mbm log scale under similar conditions.

The Bellingham Barker

H. HAGERMAN

Assistant Manager, Bridge Lumber Co., Ltd.

Barker Requirements

The management had a problem peculiar to itself in that this is a custom mill owning no logs or lumber. The requirements of the barker are listed below.

1. Since the customer is interested in a maximum recovery of lumber on any given boom of logs, the salvage of lumber had to take precedence over the salvage of chips.

2. It must be possible to by-pass the barker so that in case of a barker

breakdown the mill could continue to operate. Also, since yellow (Alaska) cedar chips are not wanted at any pulp mill, this species is not barked.

3. As the mill operates most efficiently on lengths up to 24 ft., a 26-foot barker would best serve the purpose.

4. Since 60 to 75 per cent of the mill's production is red cedar, a barker was needed that would cope with the complexities of cedar logs and cedar bark.

5. The barker should use unfiltered Fraser River water.

6. It should clean bark out of flutes, and clean the rot from split portions of logs with severe internal decay.

7. Capacity of the barker should be greater than that of the mill; there is no advantage in barking ahead in a custom sawmill.

Barker Description

The Bellingham type whole log debarker was selected as being most suitable for the purpose intended. This was a medium sized package unit, with clearance dimensions of 26 ft. by 5 ft., which also determines the maximum size of log. The barker has a wide range of capacities depending only on the water supply. In this case water is supplied directly from the river by a seven-stage centrifugal pump, delivering 400 gpm at 1400 psi.

The assembled unit consists of a main frame, two trunnion shafts with the trunnions, log stop and log loader shaft assembly (14 in. diameter air cylinder, solenoid operated), log unloader assembly (16 in. diameter air cylinder, solenoid operated), nozzle carriage with nozzle stem and nozzle head, operator's cabin and all drives.

The barker unit is unique in that it has simple components, with no complicated hydraulic seals to cause the difficulties and high maintenance costs of other hydraulic barkers. Design is simple and sturdy. It also has greater flexibility due to the possibility of moving the water jet to any spot or groove on the most difficult log. Clear observation of the log is available at all times.

Other important features include:

1. Variable speed drive of the barker rolls (35 hp DC motor),
2. Variable speed drive of the nozzle carriage (10 hp Oil Gear motor),
3. Swinging nozzle attachment and 80° nozzle turn (5 hp motor); nozzle up and down drive (7½ hp motor).

Operating Experience

Experience with this barker has been very satisfactory. Little fiber has been lost and at the same time bark removal has been thorough. The capacity of the barker exceeds the capacity of the mill. Bark-free logs can pass through directly; more time can be spent in barking difficult logs by rotating them more slowly and by using the sweep of the nozzle. The nozzle sweep is also used to remove glue-like deposits of bark that attach themselves to already barked logs.

The greatest problem was to remove the huge quantities of stringy cedar bark from the barker and into the burner, without taking all the water along. This was solved by providing ample room underneath the main machinery for a refuse trough covering parts of the infeed and outfeed log decks. Strong steel conveyors are used throughout the mill.

A few problems are not completely solved. There are baffling changes in pressure due to improper cleaning of the water screens, varying with the seasons but being particularly noticeable during freshets. Pressure at the pump is often considerably higher than at the nozzle due to trouble with the impeller. Excessive wear on nozzle holes occurs due to silt in the water. Two nozzles are used alternately to reduce wear.

In spite of these problems and of initial difficulties the barker has been a success. Breakdown times have been negligible once operations were on a routine basis. Chip quality is high, with a complete absence of bark. Chip recovery varies from 0.3 to 0.7 units Mbm log scale.

The Hansel Ring Barker

L. MacDONALD

Consultant, Canadian Forest Products, Ltd.

This company installed a slab barker in 1946 in order to produce bark-free slabs for chipping. The machine operated for the next four years but labor costs were high because of limited production.

In 1950 a survey was made of existing whole log barkers that could be adapted to a congested mill with no room for expansion, cutting logs up to 60 ft. in length. The Bellingham barker was ruled out because the mill wished to continue cutting long logs. The higher power requirements of a Simons barker (important for a mill that purchases power) would not make this barker attractive. The ring-type of barker had been under experiment for some years, the main obstacle being the ring seal. A Hansel 36-inch ring barker had been in successful use for the past two years at another mill, using relatively clean water. Because this barker looked attractive it was decided to install one in the Eburne mill.

A 60-inch spinning ring-type barker was installed to handle the large logs for Mills 1 and 2. The mill design was altered to provide a single jack ladder to feed the barker, and then to distribute the barked logs on the decks to their respective headsaws. Further, by installing a 108–inch swing cut-off saw at the top of the jackladder, two dragsaws could be eliminated from the pond and one of the two boom crews. Log lengths are kept to a maximum of 42 ft. and diameters to 48 in. The barker ring can be moved to one side without shutdown, to allow oversize logs to pass through. It is preferred practice however to accumulate large logs, quarter them, and put them through the barker as a group. The barker operates at 1,600 psi, using two 600 gpm pumps and a 300 H.P. booster pump with a 1200 gallon capacity.

Sometime later a 36-inch ring barker was placed in Mill 3. It has been less critical in its operation than the 60-inch machine but a big problem has always been the seals. In order to reduce the problem of silting of ring seals a settling tank was installed in the base of the dis-used burner. A settling time of 1–½ hours removes silt particles above 40u. Operating times are now up to 1000 hours without shutdown, and the barker has run 2240 hours. A further improvement is a molded plastic seal which will not pick up silt as readily.

This barker runs two shifts per day whereas the mill operates three shifts and cuts 150 Mbm per day. The barker has sufficient capacity to return logs to the water for a third shift, with ample time to spare for whole log chipping should we desire to do any. It operates at 1400 psi and is served by one 600 gpm pump.

A chip recovery of 0.9 units per Mbm is obtained in Mills 1 and 2, and over 1.0 units for Mill 3 because some small logs not suitable for lumber are chipped whole.

Discussion

Mr. Heller: It is obvious from the preceding papers that a mill must investigate all problems before making a choice of barker. One that is satisfactory for a particular mill might be entirely unsuitable for another.

O. C. Sawyer (Peshastin Lumber Co., Peshastin, Ore.): How many logs per shift are handled through the Nicholson barker, and what percentage are oversize?

Mr. Allison: About 300 logs with 0.5 per cent overisze.

I. B. Kay (Columbia Engineering Co., Vancouver, B. C.): Do you have any trouble with the Nicholson barker in removing bark from pockets, seams, around knots, etc.?

Mr. Allison: No. There is enough capacity to slow down and reverse if need be. We vary the feed speed rather than the ring rotation speed and still have ample production.

H. A. Schon (Westminster Paper Co., New Westminster, B. C.): What is the minimum log length, and the cost of barking per Mbm log scale, for the Nicholson barker?

Mr. Allison: Minimum log length is 12 feet but we could go shorter. The cost of barking, chipping and delivery to scow is about 60¢ per Mbm log scale.

Mr. Heller: The cost of hydraulic barking is about the same.

M. H. Mater (Mater Machine Works, Corvallis, Ore.): Will members of the panel comment on savings attributable to barking?

Mr. Allison: Yield is increased and saw cost is reduced, as noted in my paper.

Mr. Bowell: We have no exact figures; overrun, lumber prices and chip prices are interrelated. When any lumber item goes below $25/M it should be chipped. Overrun therefore goes up or down with economics. We obtain a slight increase in production. Saw costs are down because saw changes are cut in half.

Mr. Hagerman: Overrun is increased 5 to 10 per cent. Saw costs are less. The mess in the mill due to cedar bark is eliminated.

Mr. MacDonald: Overrun is improved somewhat; jogging of the saw is reduced, resulting in a smoother cut and fewer saw marks on the lumber. Improvement in production is hard to estimate due to changing log size and quality and the other changes in the mill. Over-all production per 16 hours has risen from 350–400 Mbm to an average of 700 Mbm, but other production equipment was added, besides the barker, that would account for part of the increased production. Saw costs are down and there are fewer saw changes. The sawyer can often see spikes, etc., missed when the bark is on.

P. J. G. Bentley (Canadian Forest Products): Our chip yield is 0.9 units per Mbm log scale. We endeavor to cut as much lumber as we can or, in other words, are doing our utmost to prevent the chipping of #3 and 4 common during normal operation. Saw costs have been reduced as a result of the barker installation. It is impossible to estimate the increase in production which may have resulted also, as additional changes were made simultaneously with the installation of the barkers. We do think it does help in obtaining overrun in the mill, based on the following:

At the time the barker was installed the mill cut 50 per cent fir and 50 per cent hemlock. The present cut is 80 per cent hemlock and 20 per cent fir with overrun approximately the same. Due to past experience in cutting hemlock, on which we obtained a lower percentage overrun, we feel it safe to assume that some of the result of a relatively unchanged overrun is due to the barker.

Mr. Foyston: Overrun is up about 1 per cent. Production is up, but the effect of the barker is masked by other changes in the mill. The mill is now safer and cleaner. Barked logs are smooth and slippery so that good dogging is required. A metal detector ahead of the hog is still required.

Mr. Heller: Production in our mill has improved two to five per cent since installing the barker, and by using harder steel in the inserted saw bits. Saws are changed every four hours now as against every two hours previously.

J. R. Stillinger (Cascades Plywood Corp., Lebanon, Ore.): Would members of the panel comment on improved grade recovery?

Mr. MacDonald: A relatively minor improvement is that of eliminating the bark streak on the first cut of an unbarked log.

Mr. Bowell: By eliminating loose bark and barky slabs at the headsaw the tail sawyers were reduced from two to one. A mechanical puller later eliminated both tail sawyers. The mill is much cleaner but the grade is no better.

A. P. Lloyd (Federated Co-operatives Ltd., Canoe, B. C.): Water pollution in salmon streams is important in the Interior of B.C. What has been the experience of the Coast mills?

Mr. Bowell: An Overstrom dewatering screen, used orginally, satisfied the Government Fisheries Station. We now use a screen of our own design that is equally satisfactory.

Mr. Foyston: At one of our mills we use a Dillon screen, handling up to 900 gpm., which also satisfies the Fisheries Station.

Mr. MacDonald: Two Dillon screens are used for the Eburne Sawmill barkers. These do a satisfactory job of removing bark particles from the water.

Mr. Heller: No one of the panel is able to assign a value to increased grade recovery. The panel agrees that pollution is not yet a problem, and all have been cleared by the fisheries group.

An experiment of interest is to be conducted jointly by the British Columbia Research Council and the Vancouver Laboratory of the Forest Products Laboratories of Canada. They will study the variables that affect production as between comparable barked and unbarked logs.

Modern Electric Drives for the Lumber Industry[1]

W. L. LAGERS

Industrial Application Engineer, General Electric Co., Apparatus Sales Division, Portland, Oregon

Reviews various types of adjustable speed drives, comparing characteristics with requirements of various machines used in the wood products industry. Electric drives offer such advantages as high efficiency with low maintenance cost, ease of installation, safety of operation, and versatility of control.

PRODUCTION HAS BEEN INCREASED and cost of operation decreased on many machines in the forest product industries through the use of the proper adjustable speed drive. To the mill, this means an increase in the return on machine investment, and to the operators it often means easier and more convenient control of the operation.

Electrical adjustable speed drives have been used throughout industry to increase the productivity of machines. This is especially true in the forest products industries because here, probably more than in any other industry, a machine must perform its function on a wide variety of type, size, and quality of materials.

Machine Driven at Optimum Speed

Any machine has an optimum operating speed—the maximum speed at which the machine can perform a specific job without danger to personnel or equipment and without sacrifice of quality. This optimum speed may change considerably as the job changes.

If the proper adjustable speed drive is used, the machine can always be driven at the maximum speed consistent with its capabilities for high production and quality. Thus, the adjustable speed drive has found wide acceptance as a means of increasing the return on machine investment.

The first improvement to the constant speed drive was the multi-speed drive. This is one that will run at two or more definite speeds and is accomplished by a multiple speed motor or by changing pulley ratios.

This was not the entire answer for a number of applications, however, because of the large speed change between steps. Consider the planer feed as an example. In most cases, this machine is required to surface lumber in a wide variety of dimensions, species, conditions, and quality. All of these variables affect the speed at which the lumber can be fed through a planer.

If, for the conditions encountered in a given operation, the planer could be fed at 340 fpm, and the nearest available speed was 300 fpm, this difference of 40 fpm represents a loss of 2400 linear feet per hour or 19,200 linear feet per eight-hour shift. It represents a loss, inasmuch as the machine was capable of doing more, but was limited by the drive. An adjustable speed drive could have been set at 340 fpm to take advantage of the full capacity of the machine.

Because of the difficulty involved in making a speed change with this type of equipment, further losses are often experienced. This occurs because it is more convenient to make short runs at the existing speed rather than change pulleys. The electrical adjustable speed drive, on the other hand, can be set at the correct speed easily and quickly, merely by turning a control knob.

A similar analysis can be made for many applications in the forest products industries. For example, the feed drives for edgers, resaws, trimmers, and clippers require adjustable speed drives to insure the maximum return on the machine investment. Tests have proven that, on the average, an adjustable speed drive can increase the productivity of many machines from 10 to 25 per cent.

Automatic Operation

Electrical adjustable speed drives are also used in the forest products industries to obtain automation. For example, in a hardboard plant, the forming machine drive will provide sufficient speed range to accommodate the various weights of board and the close speed regulation required for any given product. Subsequent drives may be made to follow the speed of the forming machine to result in automatic operation of the entire process.

A hardboard plant has been made fully automatic by means of the proper selection of adjustable speed drives so that it is not necessary for an operator

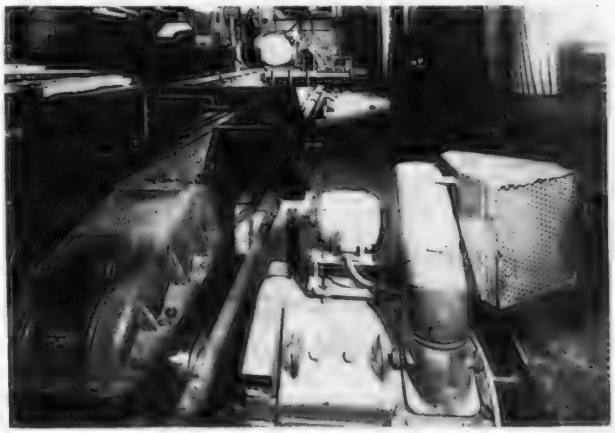


Fig. 1.—Adjustable speed drive for log carriage. Drive motor, gear reducer, and cable drum are shown in foreground. This drive provides positive operator control of all movement at extremely low energy cost.

[1] Presented at Session IV, Smog Control, Electric Drives, and Wood Preservation, FPRS Ninth National Meeting, June 21–24, 1955, in Seattle, Wash.

The Author: Warren L. Lagers joined General Electric Co. in 1948 upon graduation from Washington State College with B.S. in electrical engineering. He worked on turbine generator development and spent four years on industrial application engineering for lumber and paper industries on a worldwide basis before transferring to the Portland office in 1954.

to handle the material or touch the controls from the time the chips enter the process until the finished board is stacked for shipment.

Steam Savings

A third important contribution of the electrical adjustable speed drive is the steam and fuel savings offered. Many mills have experienced steam shortages because of their waste wood utilization program, and others are finding markets for that material, once considered worthless for anything but fuel. Other mills are finding its advantageous to eliminate the steam generating equipment entirely. These mills can no longer consider that their fuel costs them nothing. A rather high dollar value has been placed on chippable material and consideration must be given to utilizing the available steam at the most advantageous places.

Types of Adjustable Speed Drives

There are many different types of adjustable speed drives and careful consideration should be given in selecting the proper one for a given application. The popular types include:

1. The adjustable pulley mechanism.
2. The brush shifting AC motor.
3. The eddy current coupling.
4. Direct current motors and control.

Adjustable Pulley Mechanism: This device is essentially a V-belt coupling between two shafts with the input shaft driven at constant speed. The output speed is adjusted by mechanically changing the pitch diameter of the pulleys, either manually, by pilot motor, or by hydraulic or pneumatic cylinders.

Its primary advantage is in its relatively low initial cost and reasonably high speed ranges that are available. However, the time required to make a speed change is relatively long and the maintenance cost is frequently high. Also, the equipment which must be mounted at the driven shaft of a machine tends to be bulky and it is sometimes difficult to make the required space available. It is therefore, limited to relatively small ratings.

This type of equipment has been applied to some extent in the forest products industries, primarily on conveyors of various types and on some machine feed drives.

Brush Shifting AC Motor: This motor, while obtainable over wide speed ranges, is suitable for only limited applications. The rate at which the speed can be changed is relatively slow, and it should be used only in small sizes for high speed ranges.

Because of the rugged treatment that a motor receives and the unpredictable operating conditions to which it is subjected, this type of motor has a limited field of application in the forest product industries.

Eddy Current Coupling: The eddy current, or magnetic slip coupling, has been applied to numerous machines in the forest products industry. Its primary advantage is in its low initial cost and the fine degree of control available for a motoring load. It consists of an electric motor driving the input shaft at constant speed, with the speed of the output shaft being dependent upon the strength of excitation of the coupling winding and the load characteristics. The basic equipment is non-reversible, however, so that a counter torque is not available for the control of overhauling loads. A fast stop or reversal is sometimes provided by reversing the AC motor, but this has proven to be hard on the equipment and results in high maintenance costs when reversed too frequently.

The efficiency of the magnetic coupling is reasonably good at high speeds. However, when operating at reduced speed, the efficiency is low. For example, a magnetic coupling operating at 50 per cent of rated speed cannot operate at an efficiency in excess of 50 per cent. Likewise, when operating at 25 per cent of rated speed, the efficiency will be less than 25 per cent.

Thus, the proper application of the magnetic slip coupling is limited to small speed ranges, especially for large drives, and to applications where there is no overhauling load and where frequent fast stops or reversals are not required.

Direct Current Motors and Control: The direct current motor with the proper DC power supply and control can be made to perform almost any task that can be accomplished from a rotating shaft. Stepless speed control from full speed forward to full speed reverse can be provided with fast response to the operator's control device. High efficiency at any speed is characteristic of this equipment and experience has shown that maintenance costs are low. It is recognized as the most rugged of the various variable speed drives on the market. Many functions, such as speed, voltage, current, and position can be accurately regulated and the drive can be made responsive to the operator's manual control or can be automatically controlled by many other functions.

This type of equipment has been successfully used in nearly every application in the forest products industries where adjustable speed is desirable. Direct current machines with amplidyne control are used in barker, planer, log carriage, and veneer lathe drives, and the automatic electronic control that can be provided with this equipment has contributed to the automation necessary in processes such as the hardboard plant.

Thus, the various types of adjustable speed drives and the numerous equipments available for control offer to the forest product industries many opportunities to increase the productivity of machines. There are, however, many problems yet unexplored where this equipment can improve operations. These problems should be studied and solved, for only through progress can the present status of these industries be retained or improved

Discussion

Frank Holland (Consultant): What are the advantages of magentic clutch over the brush shifting a-c motor?

Mr. Lagers: The primary difficulty with the a-c brush shifting motor, as manufactured in the United States, has been the physical arrangement making them difficult to maintain in plant operation. Experience has indicated that these motors have not satisfactorily withstood the severe abuse subjected to them in the lumber industry. However, these motors have been completely redesigned to more fully meet the requirements of industry in general, and we feel that future experience will indicate that they are satisfactory for some applications in the lumber industry. I understand that this type of motor, as manufactured in England, has been used successfully for many applications in Europe. We do not know whether the European application is subjected to as severe abuse as in the United States.

A. G. Bell (B. C. Forest Products Ltd.): How does cost of application of d-c motors affect their use in the lumber industry?

Mr. Lagers: There are many adjustable speed d-c motors in use in the lumber industry today and our experience has indicated that, while the number of components required for such a system may be greater than that required for other systems, the maintenance cost is quite low. These machines are very rugged in construction and have withstood the severe lumber duty application quite well. The direct current adjustable speed drive is the most expensive of the various systems, in many cases, but the advantages experienced by the mills, such as increased production at lower operating costs, have made this type of equipment very popular.

Around the World in Forest Products Research and Development

Reinforcement of Cabinet Furniture

London, England

• Construction of cabinet furniture has been studied by the Furniture Development Council Research Dept. to find ways in which the material content might be reduced without any adverse effect on serviceability of the finished article.

Among the effects of an arbitrary reduction in material content is the possibility of overall distortion due to an uneven floor or unsymmetrical loading. This affects the fine clearances essential for proper functioning of doors and drawers.

A wardrobe is, basically, a 5-sided box. This is much less rigid than a closed box and insertion of doors on the sixth side does not increase rigidity. The open side must thus be reinforced which is done by means of a rectangular frame, inverted T-shaped, U-shaped, or L-shaped construction.

The efficiency of material utilization in these four constructions has been investigated by mathematical analysis. First, assuming a fixed material content, the optimum dimensions were found for the members of the various reinforcements. The optimum constructions for each reinforcement have, in general, different rigidities. The inverted T reinforcement is more rigid than the rectangular frame for all proportions of the open face, whereas the U reinforcement is advantageous only when the horizontal side of the open face is larger than about 1½ times the vertical side. The L reinforcement is as efficient as the rectangular frame for all proportions of the open face. These results apply only to front frames made of solid timber of rectangular cross sections.

Another way of reinforcing cabinet furniture is by increasing the torsional rigidity of one or more panels. When a cabinet distorts, all of its five panels twist. The angle of twist in each of the five panels is in a fixed relationship to the twisting of other panels and to the overall distortion of the cabinet. Thus twisting of the panels cannot occur without overall distortion of the box and vice versa, and distortion can be reduced by reinforcing the top, the bottom, or one side. The most elementary method is to increase the thickness of the panels, but this would not be economical because of the large volume of timber required. It would be more satisfactory to reinforce one panel with a closed box construction and the rigidity of this panel will depend upon the distance between the top and bottom of the box. Alternatively, the panel can be reinforced diagonally.

Research Report No. 6, The Structural Analysis of Cabinet Furniture, by T. Kotas, contains a full mathematical treatment of the work to date. Copies are available at $4 from The Furniture Development Council, 2–4 Dalmeny Ave., London N7, England. A practical report now being prepared will concentrate on implication of the results and condensing the results into a series of simple principles to help cabinet manufacturers use timber in the most effective manner. Copies of this report, Research Note A5, will be available at $2 each.

FDC Tech. Bull. V. 5, No. 29

Norway

• **The Influence of Water Quality on Water Absorption and Thickness Swelling of Fibre Building Boards.** K. Helge, The Norwegian Pulp and Paper Research Institute, Vinderen.

In connection with an intended Scandinavian proposal for standardization of methods of testing wallboard, the influence of the water quality on the water absorption and the thickness swelling has been investigated at the Wallboard Division of The Norwegian Pulp and Paper Research Institute.

The experiments were performed with hardboards from three Norwegian mills and the following qualities of water: tap water and distilled water, boiled tap water and boiled distilled water, water with 30 grams NaCl per liter, hard water, and six different buffer solutions with pH values varying from about 2.5 to 8.0.

The sample sheets consisted of 3½ mm hardboard from each of the mills, cut into test pieces 15 by 15 cm. The five test pieces used for each experiment were taken randomly from the respective sheets.

Before testing, the specimens were conditioned for 96 hours in an atmosphere of 65% relative humidity and 20° C. The pieces were weighed to an accuracy of 0.1 gram and the thickness measured to an accuracy of 0.01 mm. The thickness of each test piece was reported as the mean of five measurements, taken at the center of the piece and at the diagonals in a distance of 5.0 cm from the four corners.

The test pieces were immersed in water of 20° C. for two hours, and excess water then was wiped off. They were weighed and the thickness measured. Then they were immersed in water for another 22 hours and the above procedure was repeated.

The values of the water absorption seem to be comparatively unchanged if the pH value of the water is kept below 7 before and during testing. When the pH value is raised above 7, a noticeable increase in water absorption takes place, and the same happens even if the pH value falls below 7 during testing. The thickness swelling is not much influenced by such a raise in the pH value, but even here a certain increase may be observed.

No differences between the effects of tap water and distilled water could be observed, and as different types and amounts of inorganic salts were used for preparing the buffer solutions, the content of inorganic components in water neither seems to be essential if the pH value is kept below 7. Because of its high pH value, hard water should not be used for water absorption tests.

It may be proposed that a possible standard procedure for estimating the water absorption and thickness swelling of fiber building boards stipulates distilled water or ordinary tap water with a pH value below 7.

New Zealand

• Two promotions to meet the needs of New Zealand Forest Products Ltd. $20 million expansion program were announced recently by Sir David Henry, Managing Director. M. R. Buckett was appointed General Manager and J. T. Christiansen General Superintendent of the Kinleith Industries. Buckett started as Utilization Officer 17 years ago and for the past eight years had been Assistant General Manager. Christiansen was formerly Vice Consul for Finland and has had extensive experience in the pulp and paper industry. The company owns 176,000 acres of Monterey pine forests as well as chemical pulp, kraft paper and timber mills. It employs 2,200 people, expects to increase to 4,000 when the expansion program is completed.

Abstracts From Current World Literature

Veneer and Plywood

Wood, A. D. Douglas Fir plywood industry. *Timb. T. J.* 214 (4121), 1955 (86–7).

Describes the expansion of the industry in Oregon, California, Washington and British Columbia, with mill censuses of 1936 and 1955, the shift southward in the U.S.A., types of plywood made, the use of tropical species for facing, machinery giving improved utilization, the activities of important firms, and the development of integrated utilization. [For. Abs. V. 17, No. 1]

Glues and Gluing

Marian, J. E. The correlation of 21 variables of the gluing process for wood and similar materials. *Medd. svenska Träforsknlnst. (Träteknik)* No. 68*B*, 1955.

A table is given showing the interrelationship of 21 variables (8 concerning the conditions during gluing, 8 the properties of the glue, and 5 the properties of the wood, including the direction of the glue line in relation to that of the fibres). Symbols indicate direct or inverse relationship between a pair of variables, or that there is no relationship. Examples of the uses of this table are given. [For. Abs. V. 17, No. 1]

Pulp and Paper

Can nitric acid pulping succeed commercially? *Paper Tr. J.* 139 (24), 1955 (22, 24–5).

A detailed description of the Delbay process covered by U.S. Patent No. 2,571,-993. It is claimed that this cold process combines high yield and high-quality pulp with low plant investment and low production cost. [For. Abs. V. 16, No. 4]

Properties

Ollinmaa, Paavo J. The structure and properties of coniferous compression wood. *Paperi ja Puu* 37, no. 11:544–9 (Nov., 1955). [In Finnish; English summary]

The formation and physiology of coniferous woods containing compression wood (I), their marco-, and micro-, and submicroscopical characteristics, chemical composition, physical and strength properties, and the practical significance in the utilization of (I) for various purposes are discussed. It has been found that the location of (I) in coniferous trees is governed by the effect exerted when a leaning trunk is returning to normal position and that growth hormones are associated with its occurrence. The interdependence of the excessive warping of the stem and the direction of the formation of (I) have been examined in the case of pine. The tracheids of (I) have, in general, been found to be shorter than those from normal wood and to have thicker walls. The submicroscopic structure of the walls also differs from that of normal wood, accounting in part for the exceptional shrinkage and strength characteristics of (I). The subnormal cellulose and above-normal lignin content of (I) are significant raw-material properties for the paper industry. The strength characteristics of (I) are generally no better than those of ordinary wood; they are often a disadvantage because of the higher weight/volume unit of (I). Seasoning has less effect on the strength of (I) than on that of ordinary wood. [Bul. Pap. Chem. V. 26, N. 5]

M. McCoy–Hill. Timbers of Tanganyika. *Timber Technology,* Vol. 62 No. 2186, December 1954, p. 602.

Describes a timber which is suitable for cabinet work and heavy items of furniture. Its botanical name is *Entandrophragma bussei,* and the author suggests that 'bussei' should be adopted as the common name.

The heartwood is a rich reddish brown with purplish and lighter streaks. There is a prominent, almost black lustre on all surfaces. The tangential surface shows a prominent ripple figure, and the radial surface is flecked. The grain tends to be rather wild and the wood is dense and uniform with an average weight of 52 lb. per cu. ft. The flat sawn boards tend to distort in air seasoning, but quarter sawn pieces are comparatively very stable.

The timber is tough and hard, and very resistant to splitting on the radial and tangential surfaces. It is resistant to impact on all surfaces, but shows little endurance under load. The timber is rather resistant to the saw, but with care a very clean cut can be obtained. There is slight plucking of the grain during planing, but a clean finish can be produced and no filling is necessary before polishing. The underside must be supported during drilling and chiselling. The nail and screw holding properties are very good. [F. D. C. Tech. Bul. V 5, No. 26]

Wood Preservation

Sakornbut, S. S. and Morrill, H. L. Detection of pentachlorophenol in treated wood. *Analyt. Chem.* 27 (8), 1955 (1259–61).

Pentachlorophenol in treated wood was detected by formation of crystal violet. During colour development, oxidation by air was avoided, using N or CO_2. The minimum pentachlorophenol concentration detectable in treated *Pinus ponderosa* sapwood was estimated as 0.022%. [For. Abs. V. 17, No. 1]

Sap-stain investigations. *Rep. For. Prod. Res. Bd., Lond.* 1954, 1955 (30–1).

In material infected in the laboratory by *Diplodia* spp., which cause sap-stain in many tropical woods, the fungus was killed when subjected to 55° C. for 1/7 hr., and survived for 4, but not 16 hours at 51–52°. It was rather more resistant, surviving to ½ hour at 60°, in naturally-infected wood in which its mycelium was probably more mature. It is probably necessary to expose hardwoods stained with *Diplodia* to 65° for at least 1 hour to ensure killing the fungus throughout the piece. *D. theobromae,* in sticks of *Gonystylus* spp. 15 cm. long and coated with wax to prevent superficial growth, penetrated the whole length along the grain in 19 days at 22°. [For. Abs. V. 17, No. 1]

Finishing

Fluid Glass. Fluid Glass Products Ltd. The Philip Flooring Co. Ltd.

This synthetic finishing material is similar to the others on the market at the present time, but is based on a different copolymer. No accelerator is required, and the material is easy to apply either by brush or spray. The material is said to be completely cigarette-proof, non-scratching, unaffected by hot water, grease, alcohol, etc., and non-yellowing. [F.D.C. Tech. Bul. V. 5, No. 29]

Barking

Liiri, O. Log barking by machines. *Tied. Valt. tekn. Tutkimusl.* No. 136. 1955. pp. 179.

The construction, operating principles, and technical data of barking machines used in Finnish sawmills are reported, with information on capacity, breakdowns, power consumption, etc., based on practical experience. New machines, still under construction or at the design stage, and old and new machines from other countries are also described. Costs of barking in Finland are discussed. Information is given on methods and machines used in removing bark from slabs, edgings, and chipped wood, and on the use of bark. A number of barking machines not designed for use at sawmills and plywood factories are briefly described. (The English summary is purely indicative. There are many tables and illustrations, with Finnish legends, and an index to nearly 100 machines mentioned.) [For. Abs. V. 17, No. 1]

The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin by the Institute of Paper Chemistry, subscription price $25 per year. This Bulletin publishes over 3,600 abstracts per year on subjects of interest to manufacturers of pulp, paper, fiberboard and allied products.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society. Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

FORESTRY ABSTRACTS, published quarterly by Commonwealth Agricultural Bureaux, Farnham Royal, Slough, England, subscription price $8.40 per year. The abstracts are prepared by the Commonwealth Forestry Bureau, Oxford, England, and include a Forest Products and Utilization section. This section contains over 1,500 titles and abstracts per year from literature in some 30 languages, covers all aspects of forest utilization.

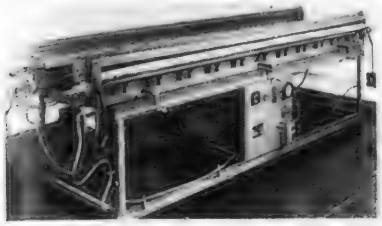
TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL is published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England. The Technical Bulletin publishes hundreds of abstracts and reviews from world literature annually, relating to the various phases of the furniture manufacturing industry. Subscription price is $5 per year.

FPRS News-Digest, Continued

Postforming Machine

The Grace Incrematic Postforming Machine which shapes flat sheets of laminated plastic to coved backs or fully formed tops is now being produced by Grace Fabri-Tool Co., 1238 Chase Ave., Cincinnati 23, Ohio.

After placing a sheet of postformed grade laminated plastic in the machine and positioning against stops, the operator merely presses the starter button. An electrical hydraulic unit makes postforming fully automatic, returns to its original position after 6-minute cycle.



Upon removing from the machine, the sheet is ready for veneering. Controlled spring-back requires no restraint in cooling as bend is cured into sheet as part of the operation.

Air Control Valve

A new valve which reportedly improves the efficiency of air suction systems and dust collectors has been developed by the Kindt-Collins Co., 12651 Elmwood Ave., Cleveland 11, Ohio. Designed to accommodate 3- to 8-inch openings, the valve is available in 110, 220, and 440 volt versions.

The unit is useful for grinding and polishing machines, joiners, sanders, table and band saws, and other machines producing dust or shavings. It operates automatically to concentrate the suction of the collector only at the machines in operation, and presents an unobstructed passage for the air stream when open, eliminating clogging.

Industrial Veneer Trim

A new economy package of Weldwood Flexible Wood Trim, designed to more adequately serve the needs of the woodworker and cabinet maker, is being offered by U. S. Plywood Corp., 55 W. 44th St., New York 36.

The trim is a tape of genuine wood veneer 1/85 of an inch thick mounted on a latex impregnated paper backing. The new industrial package contains 200 feet of trim in 25 8-foot lengths of a single wood specie.

The standard width of the wood trim is one inch, but for industrial uses wider strip up to 49 inches is available on special order. The tape is available in a variety of woods including mahogany, oak, walnut, birch, fir, and Sonora. It may be applied with any quality wood glue with no heat or clamping required.

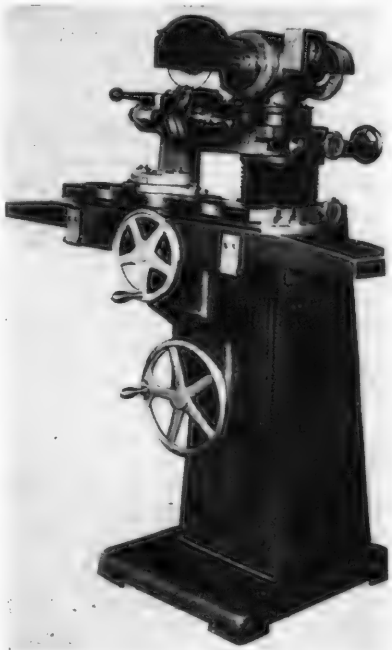
Adhesives Booklet

Catalin Corp. of America, 1 Park Ave., New York 16, N.Y., has published a new booklet on its urea, modified urea, phenolic, and resorcinol wood adhesives. It includes a "ready reference table" to assist users in selecting resins and gives detailed information on their proper use. Copies may be obtained from Robert Woodard, Advertising Manager, at the above address.

Cutterhead Grinding Fixture

A cutterhead grinding fixture for their 106–A grinder has been developed by Dependable Machine Co., Inc., Greensboro, N. C. The new fixture has attachments which are used for setting both straight and milled-to-pattern knives and for dressing the grinding wheel.

The ball bearing table of the 106–A has been made universal and can be swiveled up to 25°. The single spindle



motor has been replaced with a double spindle motor. Time can be saved by swinging the turret mounted motor around, rather than changing grinding wheels.

The new G–12 fixture has a 12-notch index head which positions the knife for grinding 2, 3, 4, 6, and 12-knife heads. Index heads are also available for 8- and 10-knife heads.

Slab Barkers

Two models of slab barkers are being produced commercially by Hosmer Machine and Lumber Co., Contoocook, N. H. The S–3 is recommended primarily for use on hardwood and fresh Southern pine at smaller sawmill installations. The S–4, shown in the photo, is for use on any species of hardwood or softwood and has a

higher production capacity for larger sawmill or slab concentration yard use.

Slabs and edgings are conveyed through the barker on a heavy rubber belt with articulated hold-down rolls. Slabs up to 17 inches wide, 8 inches high, and any length may be processed. Production averages over two cords per hour, it is reported.

Bark removal is accomplished by a rotating hammerhead, with four sets of 8-inch steel hammers. Forward and back throw of the hammers are cushioned by shock absorbers to prevent hammer breakage and wear. The hammers are shaped from 5/8-inch chrome-molybdenum steel plate and are induction hardened for wear resistance.

Portable Spray Rig

A simple portable spray rig for application of Permatox 10S sap stain control chemical in remote timber cutting areas has been designed by Chapman Chemical Co., Box 138, Memphis 1, Tenn. Plans and materials list for construction of the spray rig are available free from the above address.

By using the new spray rig, freshly sawn lumber can be treated on the spot by portable sawmill operators and others doing woodland cutting in areas removed from larger mills with conventional dipping facilities. Boards are passed horizontally on rollers between whirljet nozzles through which the protective liquid is pumped. Excess solution is collected in a pan and returned by gravity to the supply drum for re-use.

FPRS News-Digest, Continued

NEW PUBLICATIONS

Fungus Enemies of Hickory. W. A. Campbell and A. F. Verrall. Hickory Task Force Report No. 3. Southeastern Forest Experiment Station, Asheville, N. C.

Effect of Soaking Position on Treatability of Pine Fence Posts. C. S. Walters and W. L. Meek. Reprint from Forest Science, V. 2, No. 1, March, 1956.

Time-Temperature Study in Small Charcoal Kiln. H. E. Troxell and D. I. Campbell. Research Note No. 4, Colorado A & M College, Fort Collins, Colo.

A Site Index Classification for Pondersoa Pine in Northern Colorado. E. W. Mogren. Research Note No. 5. Colorado A & M College, Fort Collins, Colo.

The Installation of Wood Block Finish Flooring by Adhesive Bonding. Building Research Institute, National Academy of Sciences 2101 Constitution Ave., Washington 25, D. C. (In Print). Report of a BRAB study requested because of a lack of uniformity in minimum property requirements throughout the country, according to FHA. Report contains BRAB Special Advisory Committee's conclusions and recommendations, design and installation guides, definitions, related information and a survey of wood flooring contractors.

Pulpwood Cull and Void Tables. Technical Note No. 38, Forestry Dept., University of Maine, Orono. The series of tables make it possible to determine the degree of loss in cordage in piles of 4-foot pulpwood due to defective pieces and void spaces caused by poor piling, knots, crooked pieces, and butt flare.

Kiln-Drying Oregon Maple Paper Roll Plugs. B. G. Anderson and W. Williams Jr. Oregon Forest Products Laboratory, Corvallis.

Behavior of Certain 3-Hydroxylflavanones Toward Bases and Basic Salts. E. F. Kurth, H. L. Hergert, and J. D. Ross. Oregon Forest Products Laboratory, Corvallis.

Lateral Test on a 20- by 60-Foot Roof Diaphragm with Stapled Plywood Sheathing. J. W. Johnson. Oregon Forest Products Laboratory, Corvallis.

Strength and Stiffness of Random-Length, End- and Center-Matched 2 by 6 inch Douglas Fir Decking. R. A. Currier. Oregon Forest Products Laboratory, Corvallis.

Strength Tests on Full-Scale Plywood-Sheathed Wall Sections. R. A. Currier. Oregon Forest Products Laboratory, Corvallis.

Timber Resources. C. D. Chase and A. G. Horn. Michigan Forest Survey, Mich. Department of Conservation. Timber resource report for six counties on western side of lower peninsula of Michigan.

Nail Popping, Its Causes and Prevention. E. George Stern. Bull. 24, Virginia Polytechnic Institute, Blacksburg, Virginia.

Aerial Photography as a Practical Aid for Forest Inventory. von H. Bauman, translated by C. R. Hacker. University of British Columbia Faculty of Forestry, Vancouver, B. C.

Mill Residues in Three Oregon Counties. S. E. Corder and D. R. Godney. Information Circular 8, Oregon Forest Products Lab, Corvallis, Ore. Gives results of joint survey in western Oregon by Pacific Northwest Forest and Range Experiment Station and the Oregon Lab to determine volumes of wood residues available.

Figure Types in Mahogany. Mahogany Association, Inc., 666 Lake Shore Drive, Chicago 11, Ill. $1.00. Reproduces 40 plates of mahogany veneers in a variety of figures and patterns, including several that are comparatively rare.

Progress in the Utilization of Sawmill Waste for Pulpwood. J. H. Jenkins, Forest Products Laboratories of Canada, Ottawa. Reprint from Pulp and Paper Magazine of Canada.

People and Timber. Misc. Pub. 721, Forest Service, USDA, Washington 25, D. C. Non-technical booklet on the timber situation, based on Timber Resource Review.

Statistical Summary of Lumber and Hardwood Flooring, 1953–56. National Lumber Manufacturers Association, 1319 18th St. N.W., Washington 6, D. C. Reports latest revisions of the industry's estimates of total production, shipments, new orders, unfilled orders, and gross stocks by producing regions.

Micova. New England Council for Economic Development, with cooperation of USFS, Connecticut River Watershed Council, and state forestry agencies. Title stands for Middle Connecticut Valley and report calls for industrial development to utilize an increasing volume of surplus hardwood.

The following publications are available without charge from the U. S. Forest Products Laboratory, Madison Wis.

Bearing Strength of Wood at Angle to the Grain. J. A. Newlin. Report 1203 (revised). Describes the use of a nomograph with which the bearing strength of wood at various angles to the grain can be determined without complex calculations.

Air Drying of Lumber. E. C. Peck. Report 1657 (revised). Describes the general principles of air drying and illustrates layout of a good air-drying yard, use of pile foundations, various methods of piling, use of pile roofs and sheds, and methods of controlling air-drying defects.

Veneer Cutting and Drying Properties of Southern Pine. Report 1766–11. Presents the results of veneer cutting and drying studies on southern pine logs, including the conditions used to prepare the logs for cutting, lathe and slicer settings, drying schedule, and veneer yields.

Information Leaflet on Foreign Woods. J. M. Kryn. Report 1946. Presents data on seasoning characteristics, mechanical properties, workability, durability, and utilization of yemeri, a South American hardwood.

High-Yield Neutral Sulfite Pulps. G. Ceragioli, E. L. Keller, and G. H. Chidester. Report 2053. Presents results of research on neutral sulfite pulps obtained from aspen, white oak, and jack pine in yields that ranged from 50 to 75 per cent.

Supplement No. 2 to Stresses Induced in a Sandwich Panel by Load Applied at an Insert. W. G. Youngquist and E. W. Kuenzi. Report 1845-B.

Weathering and Decay. Technical Note 221. Describes causes and effects of two actions that will deteriorate wood in service and suggests methods of combatting or retarding these destructive forces.

Specific Gravity-Strength Relations for Wood. Report 1303 revised. Summarizes research at FPL that has shown how specific gravity of wood is related to modulus of rupture, bending strength, crushing strength, and shrinkage.

Steam Requirements in Lumber Dry Kilns. Report 1478, revised. Includes data to show the amount of steam required to dry 1,000 board feet of lumber of various hardwood and softwood species.

Approximate Methods of Calculating the Strength of Plywood. L. J. Markwardt and A. D. Freas. Report 1630. Suggests working stresses for use by engineers who design structures with Douglas-fir plywood.

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West Coast Lumberman's Assn., Portland
PENNSYLVANIA
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Perkins Glue Co., Lansdale
United States Steel Homes, Inc., Harrisburg
Wood Metals Industries, Inc., Kreamer
SOUTH CAROLINA
Lightsey Brothers, Miley
TENNESSEE
E. L. Bruce Co., Memphis
Chapman Chemical Company, Memphis
Memphis Hardwood Flooring Co., Memphis
Nickey Bros., Inc., Memphis
TEXAS
Wm. Cameron & Co., Inc., Waco
Kirby Lumber Corporation, Houston
Love Wood Products of Texas, Diboll
Wynnewood Products Co., Jacksonville
VERMONT
Beecher Falls Mfg. Corp., Beecher Falls
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Cascade Lumber Co., Yakima
Columbia Plywood Co., Inc., Seattle
Deer Park Pine Industry, Inc., Deer Park
Diamond Match Co., Spokane
Douglas Fir Plywood Association, Tacoma
The Long–Bell Lumber Co., Longview
Simpson Logging Co., Shelton
Sumner Iron Works, Everett
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ALASKA
Ketchikan Spruce Mills, Ketchikan
CANADA
B. C. Forest Products, Ltd., Vancouver
British Columbia Lbr. Mfrs. Assn., Vancouver
Canadian Forest Products Limited, New Westminster, B. C.
Dominion Electrohome Industries, Ltd., Kitchener, Ont.
Knight Mfg. & Lbr. Co. Ltd., Meaford, Ont.
MacMillan & Bloedel Ltd., Nanaimo, B. C.
A. S. Nicholson & Son, Ltd., Burlington, Ont

FOREST PRODUCT ENGINEERING

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PLYWOOD MILLS
LUMBER MILLS

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OLIVER Band Saws speed work through the machine room

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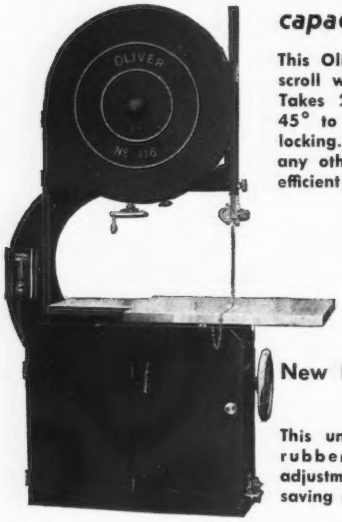

This Oliver handles a wide range of scroll work smoothly and rapidly. Takes 22" under guide. Table tilts 45° to right, 7° to left, and is self-locking. Has motor-on-shaft drive—any other type drive available. Most efficient braking system.

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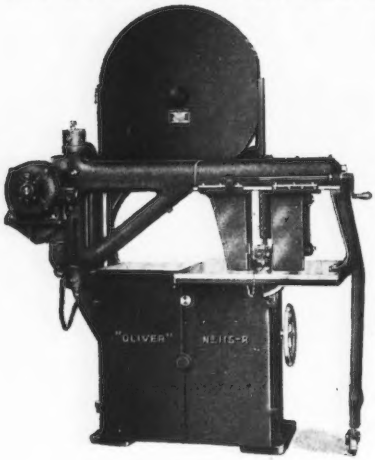
Strong, light, rigid, balanced wheels run true, steady, smooth, without vibration at all speeds.

New Power-Feed Unit —feeds 80′ a minute

This unit has micrometer fence and rubber feed-wheel with micrometer adjustment. You can attach this time-saving unit to your present band saw.

The 38-in. Band Saw also has a Band Resaw attachment for cutting Boards



This Oliver handles a wide range of work, taking 21½" under guide. The Resaw rips 10′ to 20′ a minute, stock up to 17¾" wide, 8" thick. Resawing boards to dimension saves considerable lumber. Can be quickly swung aside.

• Oliver also makes an 18" and 30" Band Saw. Their many features have made them popular among woodworkers.

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INDEX TO ADVERTISERS

Behr–Manning Company	3rd Cover
Berthelsen Engineering Works	4th Cover
Black Brothers Co., Inc.	6–A
Buss Machine Works	3–A
Chapman Chemical Co.	2nd Cover
Columbia Engineering Co.	31–A
Columbia Hardbord Co.	8–A
Koppers Co., Chemical Division	4–A, 5–A
Monsanto Chemical Co.	2–A
National Starch Products Co.	7–A
Oliver Machinery Co.	32–A
Perkins Glue Co.	14–A
W. H. Rambo	32–A
G. Siempelkamp & Co.	13–A
Standard Dry Kiln Co.	15–A
Wisconsin Foundry & Machine Co.	32–A
Yates–American Machine Co.	16–A

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SINCE introducing these 2 new tools for precision cutting of veneers in January, they have been ordered and put into use in both soft-wood and hardwood veneer plants in every section of the U. S. and Canada—from British Columbia to South Carolina, from California to Ontario.

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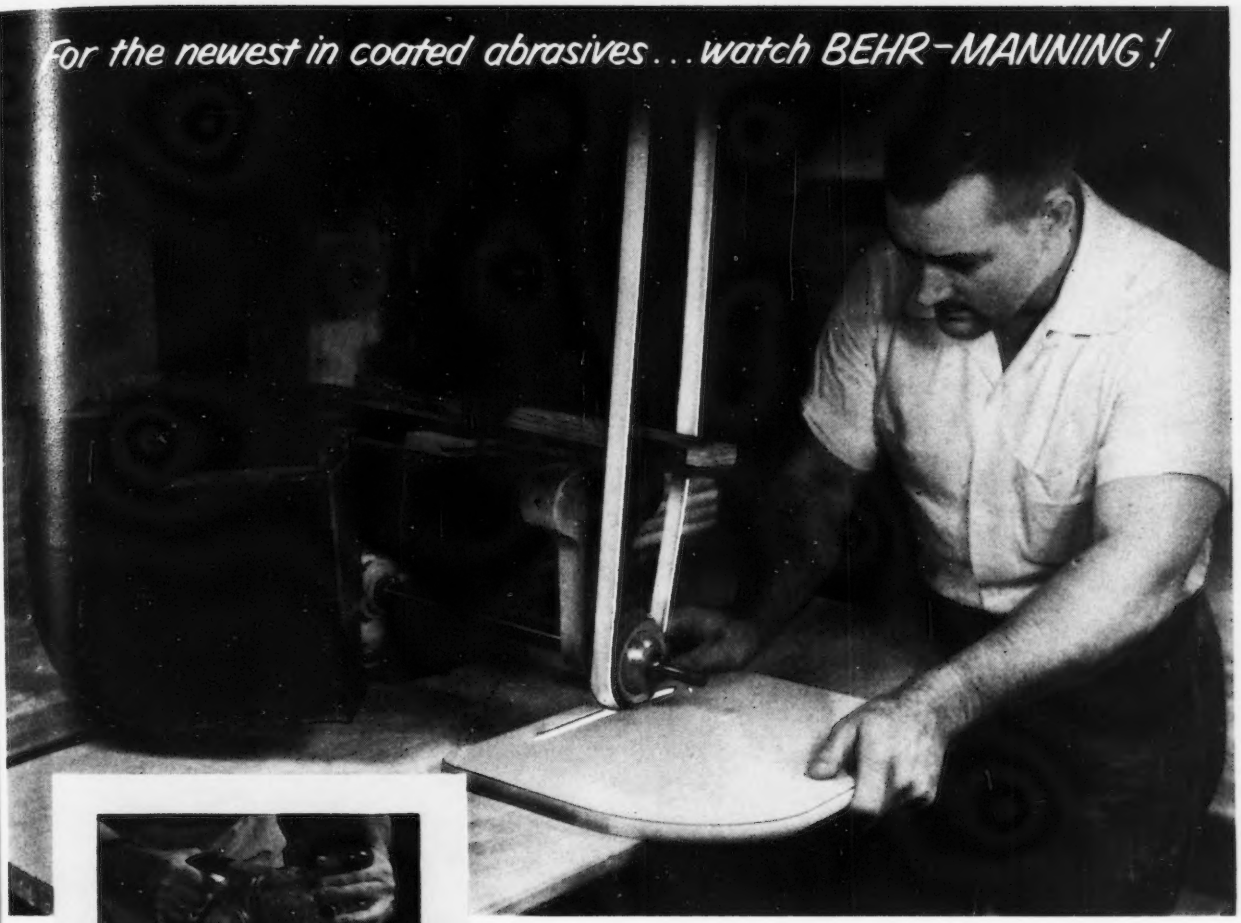

Photo courtesy of Pearson Sanding Machine Company

Garnet Belts clean up rough edges and glued edges at record-breaking speeds.

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Tufbak Paper is tops for smoother wet-sanding between coats.

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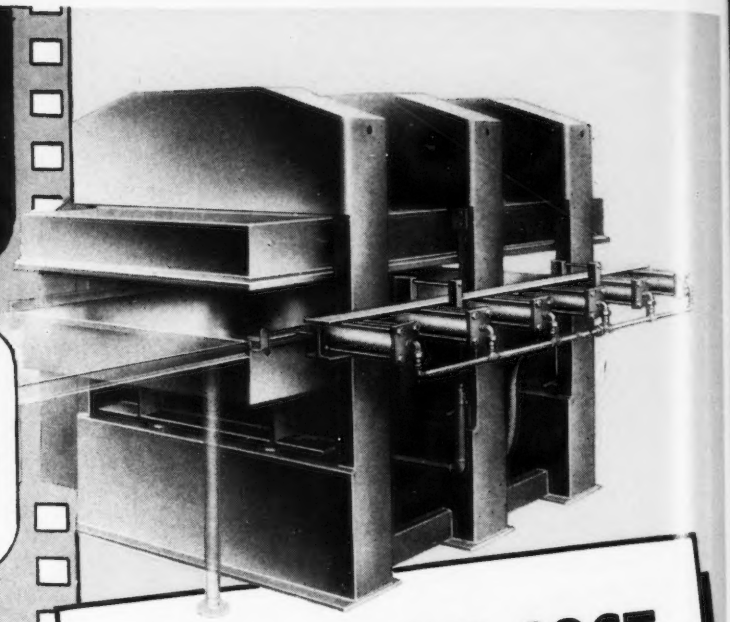

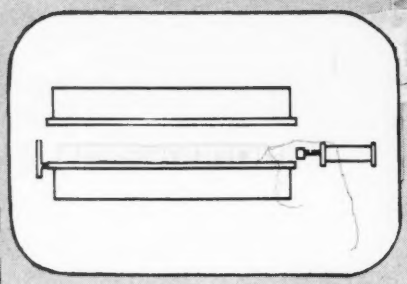

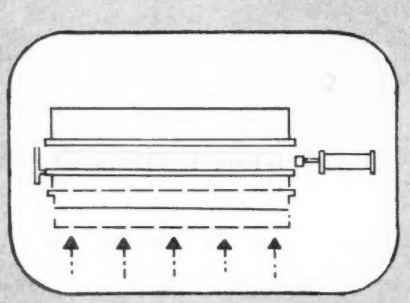

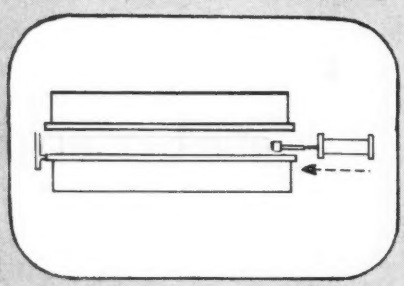

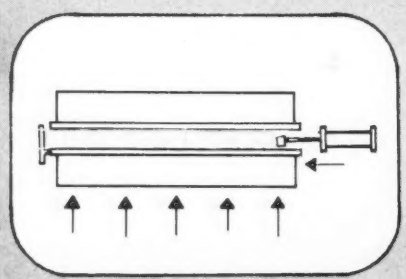

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